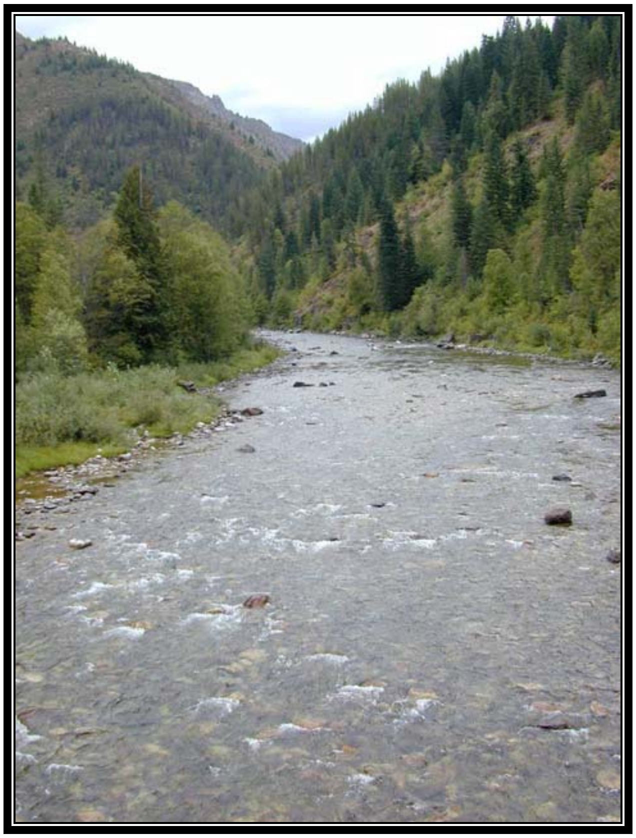
Upper North Fork Clearwater River Subbasin Assessment and Total Maximum Daily Loads



Department of Environmental Quality
October 2003

Appendix 12. CWE Road Sediment Delivery Assessment Data

The data shown in this appendix are
in an AcrView shapefile
on the diskette
in the back of this document.

Appendix 12. CWE Road Sediment Delivery Assessment Data

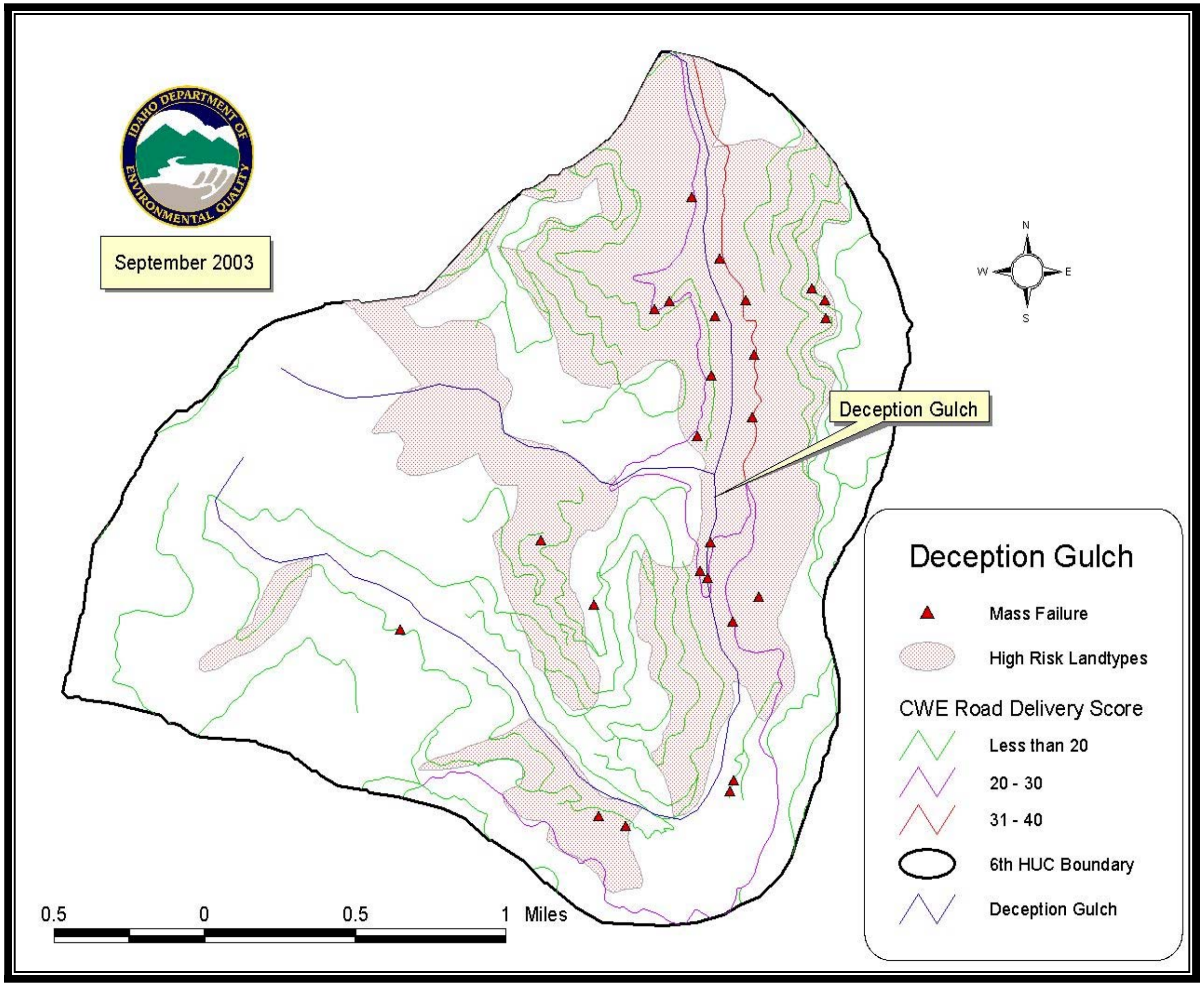


Figure 12-1. Roads Assessed Using the CWE Sediment Delivery Protocol

Table 12-1. CWE road sediment delivery data[1], road segment by road segment.

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
7,719	1.46	2	1	2	2	2	36	0
4,320	0.82	1	1	2	2	2	30	0
1,414	0.27	1	1	2	2	2	30	0
2,341	0.44	1	1	2	2	2	30	0
601	0.11	1	1	1	1	2	20	0
5,480	1.04	1	1	1	1	2	20	0
5,862	1.11	1	1	1	1	2	20	0
4,226	0.80	1	1	1	1	2	20	0
3,877	0.73	1	1	1	1	2	20	0
2,183	0.41	1	1	1	1	2	20	0
615	0.12	1	1	1	1	2	20	0
605	0.12	1	1	1	1	2	20	0
1,371	0.26	1	1	2	2	1	15	0
800	0.15	1	1	2	2	1	15	0
2,397	0.45	1	1	2	2	1	15	0
1,102	0.21	1	1	1	1	1	10	0
1,788	0.34	1	1	1	1	1	10	0
1,731	0.33	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
502	0.10	0	0	0	0	0	0	15
1,506	0.29	0	0	0	0	0	0	15
535	0.10	0	0	0	0	0	0	15
160	0.03	0	0	0	0	0	0	15
472	0.09	0	0	0	0	0	0	15
248	0.05	0	0	0	0	0	0	15
2,495	0.47	0	0	0	0	0	0	15
715	0.14	0	0	0	0	0	0	15
3,673	0.70	0	0	0	0	0	0	15
2,250	0.43	0	0	0	0	0	0	15
3,331	0.63	0	0	0	0	0	0	15
738	0.14	0	0	0	0	0	0	15
1,363	0.26	0	0	0	0	0	0	15
268	0.05	0	0	0	0	0	0	15
89	0.02	0	0	0	0	0	0	15
4,896	0.93	0	0	0	0	0	0	15
2,169	0.41	0	0	0	0	0	0	15
941	0.18	0	0	0	0	0	0	15
3,633	0.69	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
4,906	0.93	0	0	0	0	0	0	15
4,899	0.93	0	0	0	0	0	0	15
1,494	0.28	0	0	0	0	0	0	15
1,875	0.36	0	0	0	0	0	0	15
1,734	0.33	0	0	0	0	0	0	15
3,270	0.62	0	0	0	0	0	0	15
449	0.09	0	0	0	0	0	0	15
739	0.14	0	0	0	0	0	0	15
4,144	0.79	0	0	0	0	0	0	15
432	0.08	0	0	0	0	0	0	15
789	0.15	0	0	0	0	0	0	15
1,649	0.31	0	0	0	0	0	0	15
278	0.05	0	0	0	0	0	0	15
219	0.04	0	0	0	0	0	0	15
4,049	0.77	0	0	0	0	0	0	15
68	0.01	0	0	0	0	0	0	15
1,151	0.22	0	0	0	0	0	0	15
96	0.02	0	0	0	0	0	0	15
3,814	0.72	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
1,276	0.24	0	0	0	0	0	0	15
383	0.07	0	0	0	0	0	0	15
3,948	0.75	0	0	0	0	0	0	15
3,979	0.75	0	0	0	0	0	0	15
70	0.01	0	0	0	0	0	0	15
3,665	0.69	0	0	0	0	0	0	15
3,282	0.62	0	0	0	0	0	0	15
1,086	0.21	0	0	0	0	0	0	15
983	0.19	0	0	0	0	0	0	15
1,105	0.21	0	0	0	0	0	0	15
217	0.04	0	0	0	0	0	0	15
2,653	0.50	0	0	0	0	0	0	15
522	0.10	0	0	0	0	0	0	15
1,416	0.27	0	0	0	0	0	0	15
1,112	0.21	0	0	0	0	0	0	15
2,042	0.39	0	0	0	0	0	0	15
3,467	0.66	0	0	0	0	0	0	15
371	0.07	0	0	0	0	0	0	15
278	0.05	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
39	0.01	0	0	0	0	0	0	15
643	0.12	0	0	0	0	0	0	15
597	0.11	0	0	0	0	0	0	15
7	0.00	0	0	0	0	0	0	15
991	0.19	0	0	0	0	0	0	15
1,811	0.34	0	0	0	0	0	0	15
1,800	0.34	0	0	0	0	0	0	15
1,048	0.20	0	0	0	0	0	0	15
973	0.18	0	0	0	0	0	0	15
1,024	0.19	0	0	0	0	0	0	15
788	0.15	0	0	0	0	0	0	15
2,702	0.51	0	0	0	0	0	0	15
1,904	0.36	0	0	0	0	0	0	15
217	0.04	0	0	0	0	0	0	15
357	0.07	0	0	0	0	0	0	15
1,847	0.35	0	0	0	0	0	0	15
1,130	0.21	0	0	0	0	0	0	15
180	0.03	0	0	0	0	0	0	15
62	0.01	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
1,701	0.32	0	0	0	0	0	0	15
770	0.15	0	0	0	0	0	0	15
1,636	0.31	0	0	0	0	0	0	15
63	0.01	0	0	0	0	0	0	15
5,356	1.02	0	0	0	0	0	0	15
1243	0.24	0	0	0	0	0	0	15
6,003	1.14	0	0	0	0	0	0	15
2,049	0.39	0	0	0	0	0	0	15
2,530	0.48	0	0	0	0	0	0	15
61	0.01	0	0	0	0	0	0	15
1,345	0.26	0	0	0	0	0	0	15
152	0.03	0	0	0	0	0	0	15
317	0.06	0	0	0	0	0	0	15
3,675	0.70	0	0	0	0	0	0	15
1,746	0.33	0	0	0	0	0	0	15
1,777	0.34	0	0	0	0	0	0	15
742	0.14	0	0	0	0	0	0	15
151	0.03	0	0	0	0	0	0	15
1,186	0.23	0	0	0	0	0	0	15

Road Segment Length (Feet)	Road Segment Length (Miles)	Cut Slope Erosion Rating	Fill Slope Erosion Rating	Road Surface Erosion Rating	Inside Ditch Erosion Rating	Delivery Multiplier	Total Road Sediment Delivery Score	Assumed Road Sediment Delivery Score
1,179	0.22	0	0	0	0	0	0	15
278	0.05	0	0	0	0	0	0	15
97	0.02	0	0	0	0	0	0	15
512	0.10	0	0	0	0	0	0	15
6,128	1.16	0	0	0	0	0	0	15
1,124	0.21	0	0	0	0	0	0	15
1,506	0.29	0	0	0	0	0	0	15
1,387	0.26	0	0	0	0	0	0	15
864	0.16	0	0	0	0	0	0	15
447	0.09	0	0	0	0	0	0	15
4,420	0.84	0	0	0	0	0	0	15
5,912	1.12	0	0	0	0	0	0	15
53	0.01	0	0	0	0	0	0	15
2,257	0.43	0	0	0	0	0	0	15

[1] The data in this table were generated following the CWE road protocol (IDL 2000).

Appendix 13. Comparison Between Stream Temperature Prediction Models: SSTemp, *Heat Source*, and Idaho Cumulative Watershed Effects

Comparison Between Stream Temperature Prediction Models: SSTemp, *Heat Source*, and Idaho Cumulative Watershed Effects

by

Western Watershed Analysts
Lewiston, Idaho

for

Idaho Department of Environmental Quality
January, 2001

Introduction

Idaho Department of Environmental Quality (IDEQ) contracted Western Watershed Analysts (WWA) to conduct a comparison between three stream temperature prediction models: SSTemp (developed by U.S. Fish and Wildlife Service), *Heat Source* (developed by Oregon Department of Environmental Quality), and the Idaho Cumulative Watershed Effects (CWE) procedure. The first two models are process-based, and require numerous stream morphology and meteorologic input parameters. The Idaho CWE temperature prediction relationships are empirically-based on extensive water temperature measurements made throughout northern Idaho, and require only two inputs - vegetative shade level and elevation.

The Cold Springs/Cool Creek drainage in the Upper North Fork Clearwater basin was used to make comparisons between the three models. Predicted daily maximum and daily average water temperatures from each of the three models were compared to water temperatures measured in the Cold Springs/Cool Creek drainage during 1998, 1999, and 2000. The purpose of the comparison was to ascertain whether the Idaho CWE temperature relationships predicted actual temperatures as accurately as the other two process-based models. If so, the CWE relationships could be used within the context of a Total Maximum Daily Load (TMDL) allocation to determine shade levels required to maintain water quality temperature standards.

Background

The federal Clean Water Act (CWA) requires states to protect the quality of their rivers, streams, and lakes. The IDEQ has the responsibility for developing standards that protect beneficial uses of Idaho's water resources. Section 303(d) of the Clean Water Act requires the state to develop a list of waterbodies that do not meet standards. Listed streams are water quality limited for physical and biological factors, such as temperature, pH, bacteria, and dissolved oxygen. The IDEQ has proposed a TMDL program to address water quality problems, including temperature. A temperature TMDL addresses stream heating problems by linking them to watershed characteristics and management practices, establishing objectives for water quality improvement, and identifying and implementing new or altered management measures designed to achieve those objectives.

In developing a temperature TMDL, regulators must be able to identify locations within the listed waterbody where temperatures exceed water quality standards, and determine the factors (both natural and anthropogenic) that contribute to high water temperatures at those locations. Only then can the agency determine the management actions necessary to maintain the water temperature standards. To identify these factors, typically a combination of temperature monitoring at selected locations along with stream temperature modeling is utilized.

Two general types of stream temperature prediction models are available. Reach-based models predict water temperatures on a site by site basis and generally require extensive inputs to calculate the various heat fluxes associated with stream heating and cooling. Basin models are capable of predicting water temperatures over a wider area and typically require fewer input parameters, which makes them generally easier and less expensive to use in applications to entire watersheds.

Temperature Model Descriptions

Heat Source

The *Heat Source* model was developed at Oregon State University as a tool for analyzing stream temperature data (Boyd 1996). The model is used to predict effects on stream temperatures resulting from changes in various stream parameters, and allows evaluation of variations due to different management scenarios. The *Heat Source* model has been described in detail by ODEQ (1999). The code is written in Visual Basic, with an Excel spreadsheet input/output interface. *Heat Source* uses the same fundamental physical and thermodynamic concepts as many other process-based models. The fundamental premise of the model is that the water temperature at any given time and location in the stream is the result of the physical heat transfer processes between the stream and its surrounding environment. As a reach-based model, *Heat Source* predicts water temperatures at a downstream location based on some known water temperatures at an upstream location; it cannot predict stream temperatures at a given location in the stream system unless it is given water temperature inputs from an upstream location.

The model itself requires four basic types of input:

1. stream characteristics - location, aspect, wetted width, flow, etc.
2. riparian characteristics - buffer height, width, overhang, etc.

3. atmospheric conditions - air temperature, humidity, wind speed
4. hourly water temperatures at the upstream end of the reach through the course of a day

Based on these inputs, the model predicts the hourly water temperatures at the downstream end of the reach, and displays the results in tabular and graphic formats.

SSTemp

The SSTemp model was developed by the U.S. Fish and Wildlife Service Technical Services Branch (Theurer et al 1984; Bartholow 1989). SSTemp runs in a fashion similar to *Heat Source*, and many of the inputs required for SSTemp are the same or similar to those for *Heat Source*. However, SSTemp is oriented toward average daily conditions. For example, rather than inputting minimum and maximum daily air temperatures and humidities, as in *Heat Source*, SSTemp uses only daily average values of air temperature and humidity. As a result, SSTemp is designed to predict only the daily average water temperature for the reach. The SSTemp model results do report an estimated maximum daily temperature, but it is only an estimate based on empirical relations, not on heat transfer process calculations. In addition, SSTemp is implemented as an executable application, and therefore the code is not visible to, nor changeable by, the user.

Idaho Cumulative Watershed Effects (CWE)

The Idaho CWE temperature model is an empirical model based on extensive water temperature monitoring conducted throughout northern Idaho by Plum Creek Timber Company (PCTC), Potlatch Corporation, and Idaho Department of Lands (IDL). The data collection and analysis methods are described in detail in Sugden et al (1998). The results of the analysis indicated that maximum weekly maximum water temperature (MWMT), which is the average of the daily maximum water temperatures for the warmest seven-day period in the summer, can be predicted with only two parameters - elevation and canopy cover - with a correlation coefficient of $r^2 = 0.49$ (MWMT was used because most temperature standards for fish species are written in terms of the MWMT). Slightly better predictions ($r^2 = 0.58$) could be obtained by adding a third parameter - the average July-August drought index.

The Idaho CWE process (IDL 2000) uses the MWMT relationships developed in the PCTC analysis, solving the equation for canopy cover in order to predict the shade level required to maintain the various temperature standards, depending on fish species. The result is a table that estimates required canopy cover, given elevation and the appropriate temperature standard.

For our analysis, we used canopy cover and elevation as inputs to the CWE relationships to predict the MWMT for the stream reach. Additional relationships developed by Sugden et al (1998) were then used to predict instantaneous maximum and daily average water temperatures in order to make comparisons to the results of the other two process-based models.

Study Area

The Cold Springs/Cool Creek drainage was chosen for temperature modeling comparisons because of the relative abundance of available data. Stream morphology characteristics were available from stream surveys done by Clearwater BioStudies (1996), streamflow records were available for water years 1983-92, and water temperature data had been recorded in 1998, 1999, and 2000. The drainage is located in the Upper North Fork Clearwater basin, and flows into the North Fork Clearwater just downstream of Kelly Forks. The drainage ranges in elevation from 2,700 feet to over 5,800 feet, and encompasses approximately 11 square miles. The stream system was divided into 43 reaches (see Figure 1), with reach breaks taken at major tributary junctions or significant changes in stream characteristics, such as aspect, gradient, or riparian shade. A total of approximately 16 miles of stream was modeled.

Model Inputs

Heat Source

The complete set of input parameters used for the *Heat Source* model are shown in Tables 1 and 2. Table 1 shows the input values used to calibrate the model from data derived for July 27, 1998, which was the date that the warmest water temperatures were recorded in the study drainage in 1998. Table 2 shows the input values used to predict water temperatures on August 6, 1999, which was the date of warmest water temperatures recorded in that year. Stream gauge data was recorded in Cold Springs Creek near the downstream end of Reach # 41. Unfortunately, water temperature data and stream flow data were not available for any overlapping time period. Therefore, discharge of the North Fork Clearwater at the Canyon Ranger Station was correlated to discharge in Cold Springs Creek for the months of July and August from 1985 to 1992 (Figure 2). This correlation was then used to predict the flow at Reach #41 for July 27, 1998, and August 6, 1999, from flows recorded for the North Fork Clearwater. Flows for all other reach locations on those two dates were then estimated by multiplying the flow at Reach # 41 by the ratio of the drainage areas, as measured from GIS. Reach lengths were also obtained from GIS.

Latitude, longitude, stream aspect, stream elevations, and topographic shade angles were estimated for each reach from topographic maps. Average wetted width of each reach was estimated from stream survey data obtained by Clearwater BioStudies (1997). Rosgen stream types recorded by Clearwater BioStudies (1997) were used to estimate bankfull values of Manning's n, as suggested by Rosgen (1996), with adjustments made to account for low flow conditions based on recommendations by Jarrett (1984). Average stream depth and velocity for each reach were then estimated using Manning relationships.

Height and density of riparian vegetation along each reach was estimated from recent stereo aerial photography. The width of the riparian buffer was taken as one-half the height, in order to enable compatibility between input parameters between *Heat Source* and SSTemp (i.e., *Heat Source* requires buffer width as an input, whereas SSTemp requires tree crown diameter as the equivalent input).

Minimum and maximum air temperatures for each day were obtained from weather station data at Pierce, Idaho (3,150 feet elevation), and adjusted for variations in elevation using a typical lapse rate of 1.8ºC per 1,000 feet. Values of humidity and average wind speed used in the modeling were those reported for Missoula, Montana, because that was the nearest weather station location for which humidity and wind speed data could be obtained. Groundwater temperature was assumed to be equal to the average annual air temperature as reported for Pierce, Idaho, and again adjusted for elevation.

Initial runs of the model resulted in predicted water temperatures well below those actually measured on July 27, 1998. Several input parameters were therefore adjusted to calibrate the model (see Table 1). Since the air column immediately above the stream may be moister than that recorded in the open (i.e., at a weather station), average humidity was raised from 55% to 65%. Similarly, because the air temperature immediately above the water surface may be partially regulated due to its proximity to the water, the daily variation in air temperature was reduced to one-sixth of the actual measured variation, keeping the daily average air temperature the same (i.e., measured minimum and maximum temperatures on July 27, 1998, of 11ºC and 36ºC, respectively, at Pierce were adjusted to 22ºC and 26ºC, respectively, in the modeling). Because groundwater temperature is in fact not a well known quantity, the value for groundwater temperature was also raised by 8ºC, yielding the following relationship:

$$T_{gw} = 14 + 0.0018\,(3{,}150 - E)$$

where T_{gw} = groundwater temperature (ºC)
E = average stream reach elevation (feet)

To predict temperatures on August 6, 1999, the only input parameters that needed to be changed were stream flow and air temperature. Flow on that day was slightly higher than for July 27, 1998 (see Table 2). Measured air temperatures at Pierce for that date were 12ºC minimum and 32ºC maximum. Therefore, consistent with the adjustments made for the calibration on July 27, 1998, air temperatures input to the model for August 6, 1999 were 20.5ºC minimum and 23.5ºC maximum (at 3,150 feet elevation).

SSTemp

The complete set of input parameters used for the SSTemp model are shown in Tables 3 and 4. Table 3 shows the input values used to calibrate the model from data derived for July 27, 1998, and Table 4 shows the input values used to predict water temperatures on August 6, 1999.

All of the input parameters for the SSTemp model could be taken directly from or were easily derived from the inputs used for the *Heat Source* model. Initial runs of SSTemp also indicated that predicted average water temperatures were below those actually measured on July 27, 1998, although the difference was less than that encountered in the initial runs of *Heat Source*. Therefore, calibration of the SSTemp model consisted of increasing the average humidity to 65% (the same as for *Heat Source*) and raising groundwater temperature by only 2ºC (i.e., 6ºC cooler than that used for the calibration of *Heat Source*). As was true for the *Heat Source* calibration, the average daily air temperature was left unchanged (see Table 3). To predict temperatures on August 6, 1999, the stream flow and average air temperature were changed to the same values as those used in the *Heat Source* model for that date (see Table 4).

Idaho CWE

The Idaho CWE temperature model uses only two input parameters - canopy cover and elevation. These parameters are shown in Table 5, and are the same values as those used for *Heat Source* and SSTemp. The CWE prediction equation for northern Idaho is:

$$MWMT = 29.1 - 0.00262\ E - 0.0849\ C$$

where MWMT = maximum weekly maximum temperature (ºC)
E = stream reach elevation (feet)
C = riparian canopy cover (%)

In addition, the daily average temperature is predicted by:

$$T_{ave} = 0.95 + 0.83\ MWMT$$

and the daily maximum temperature is predicted by:

$$T_{max} = 0.15 + 1.04\ MWMT$$

Results

The predicted average and maximum water temperatures for each model/date combination are shown in Tables 1-5 (last two rows of each table); these values are also plotted in Figures 3-7, along with the actual measured temperatures for comparison.

Calibration of *Heat Source* for the best achievable agreement at Reach # 27 on July 27, 1998, resulted in under-prediction of temperatures at Reach #41 for that date (see Figure 3). However, *Heat Source* temperature predictions for August 6, 1999, were very close to measured values at reach #41, and somewhat high for Reach # 27 (Figure 4). Calibration of SSTemp for the best possible agreement with the average measured temperature at Reach # 27 on July 27, 1998, also resulted in under-prediction of the average temperature at Reach #41 for that date (Figure 5), but SSTemp over-predicted maximum temperatures at both locations. SSTemp predictions of average temperatures for August 6, 1999, were fairly close to the measured values, but SSTemp again over-predicted maximum temperatures (Figure 6).

In order to provide an estimate of the "goodness of fit" of the model calibrations, the root-mean-square (RMS) of the deviations between simulated and measured temperatures for July 27, 1998, were calculated for each model (see Table 6). The RMS values were calculated for all measurements, and also for maximum temperatures only, because maximum temperatures are the primary quantity of interest in a water quality context. Table 6 indicates that with our model calibration, the average error in temperature predictions that might be expected from *Heat Source* would be a little more than 1ºC, and the average error in maximum predicted temperatures might be about 1.5ºC. Similarly, given our model calibration, the average error in temperature predictions that might be expected with SSTemp would be around 1ºC, or possibly a little less for average water temperatures.

RMS errors for *Heat Source* temperature predictions on August 6, 1999, are approximately 1.3ºC to 1.6ºC (Table 7), which are consistent with the calibration RMS deviations for the *Heat Source* model. RMS errors for SSTemp temperature predictions on August 6, 1999, are approximately 1.3ºC to 1.7ºC (Table 7), which are considerably higher than the calibration RMS deviations for SSTemp.

The results of the CWE prediction equations are shown in Figure 7. Because its inputs are not dependent upon the specific date, the CWE model predicts water temperatures that would be found during the warmest period of a typical summer in northern Idaho. Therefore, for comparison purposes, Figure 7 shows measured temperatures for the warmest days in 1998, 1999, and 2000; the averages of these measurements are shown in Table 7. Comparing the CWE predictions to these average measured values shows RMS errors of 1.0ºC to 1.2ºC for the CWE model (Table 7).

Discussion

The best calibrations of the *Heat Source* and SSTemp models that we were able to achieve through adjustment of humidity, air temperature, and groundwater temperature inputs were on the order of 1ºC to 1.5ºC (Table 6). RMS errors for *Heat Source* temperature predictions of 1.3ºC to 1.6ºC (Table 7) were entirely consistent with the calibration RMS deviations for the *Heat Source* model. In other words, given our ability to calibrate the *Heat Source* model for this drainage, we would not expect to be able to predict temperatures much better than this on average.

RMS errors for SSTemp temperature predictions of 1.3ºC to 1.7ºC (Table 7) were considerably higher than the calibration RMS deviations for SSTemp. Possible explanations for this poorer prediction performance are either we adjusted the wrong input parameters to calibrate the model, or the SSTemp model does not perform well under varying atmospheric and stream flow conditions. The fact that we were able to obtain consistent results with a similar calibration of the *Heat Source* model suggests that the former is unlikely. Furthermore, even when calibrated to predict average temperatures with reasonable accuracy, SSTemp consistently over-predicted maximum temperatures in all conditions tested for this drainage, indicating a systematic bias in the model's prediction of maximum temperatures.

RMS errors for the CWE temperature predictions of 1.0ºC to 1.2ºC (Table 7) were slightly better than those for either of the other two models, suggesting that the CWE model performs at least as well as the other models in a drainage such as Cold Springs Creek. In addition, the

CWE model requires no calibration, and also involves substantially less time and effort in obtaining the necessary model inputs and executing the model calculations.

Conclusions

Water temperatures were modeled during summer low flow conditions in approximately 16 miles of stream in Cold Springs Creek, a small (11 sq. mi.) headwater drainage in the Upper North Fork Clearwater basin, using three different temperature models, and compared to temperatures measured in 1998, 1999, and 2000. The *Heat Source* and SSTemp models require extensive inputs regarding stream and riparian characteristics and atmospheric conditions. The CWE model requires only elevation and canopy cover as model inputs.

After calibration, *Heat Source* predicted average and maximum water temperatures to within about 1.5ºC or less. Accuracy of predictions from the SSTemp model was similar to that for *Heat Source*. However, SSTemp appears to consistently over-predict maximum temperatures. CWE predictions of average and maximum water temperatures were as good as or slightly better than predictions from the other two models. CWE exhibits additional advantages in its simplicity of inputs and rapid execution.

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Figure 1. Stream Reaches Defined for Cold Springs/Cool Creek Drainage

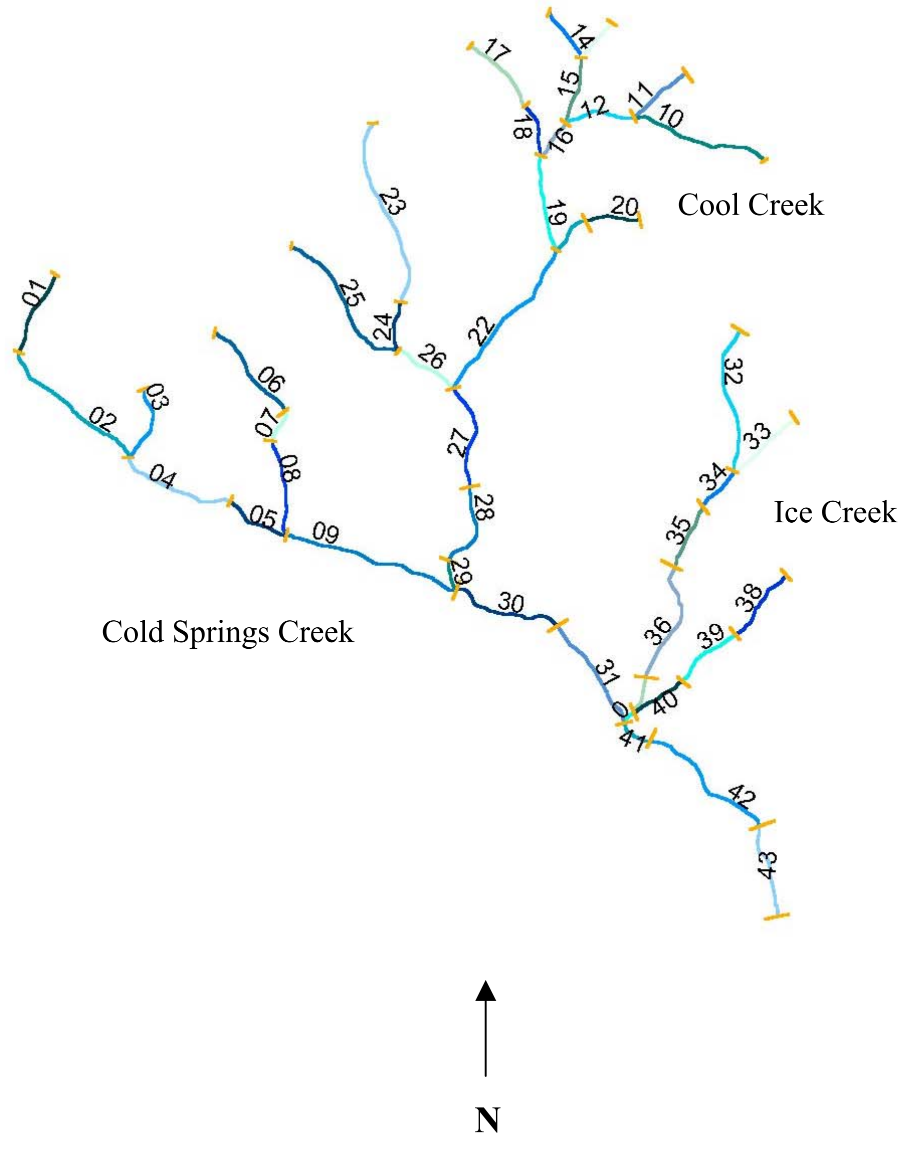

Figure 2. Stream Gauge Correlation

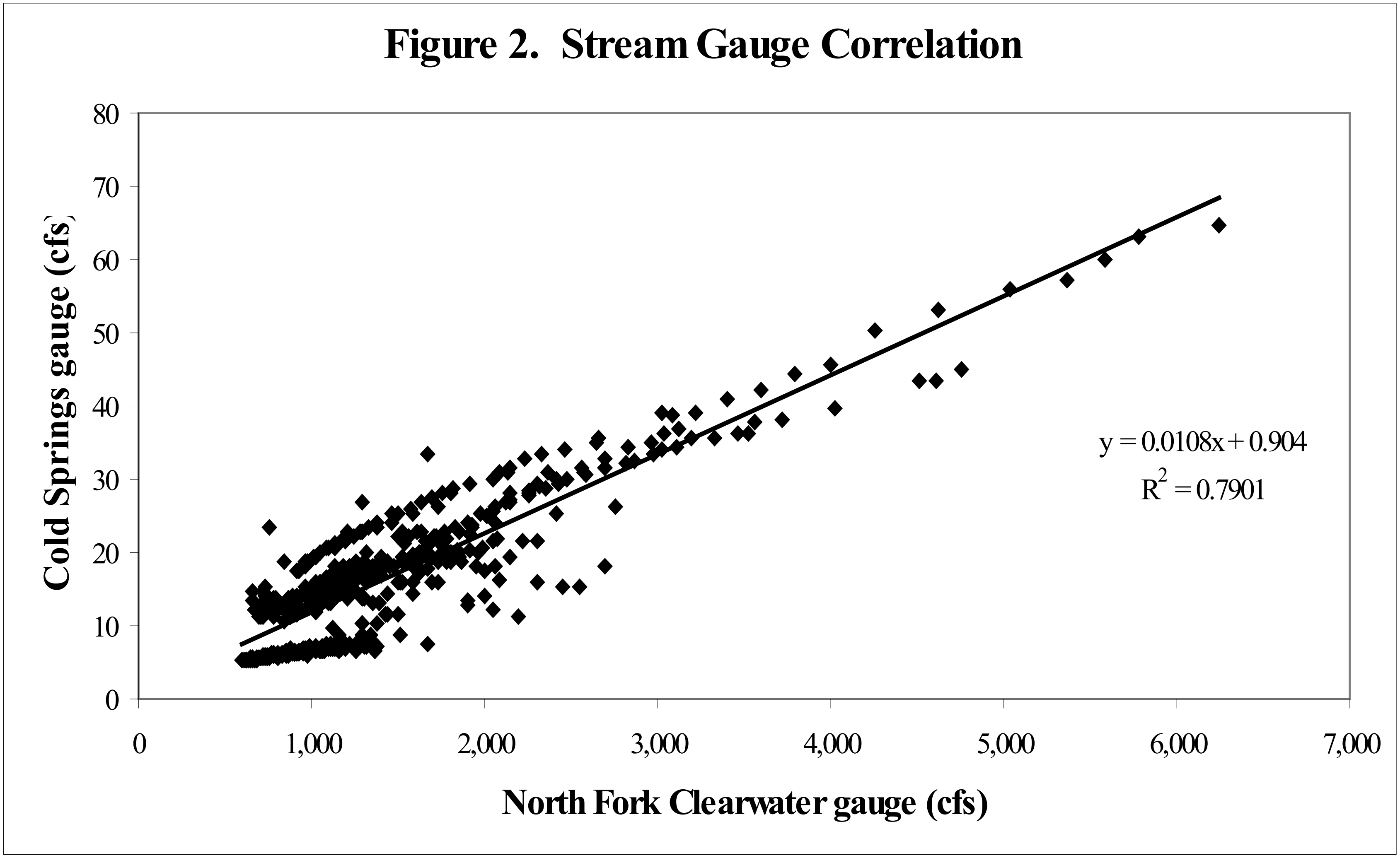

Figure 3. He*at Source* Calibration – 7/27/98

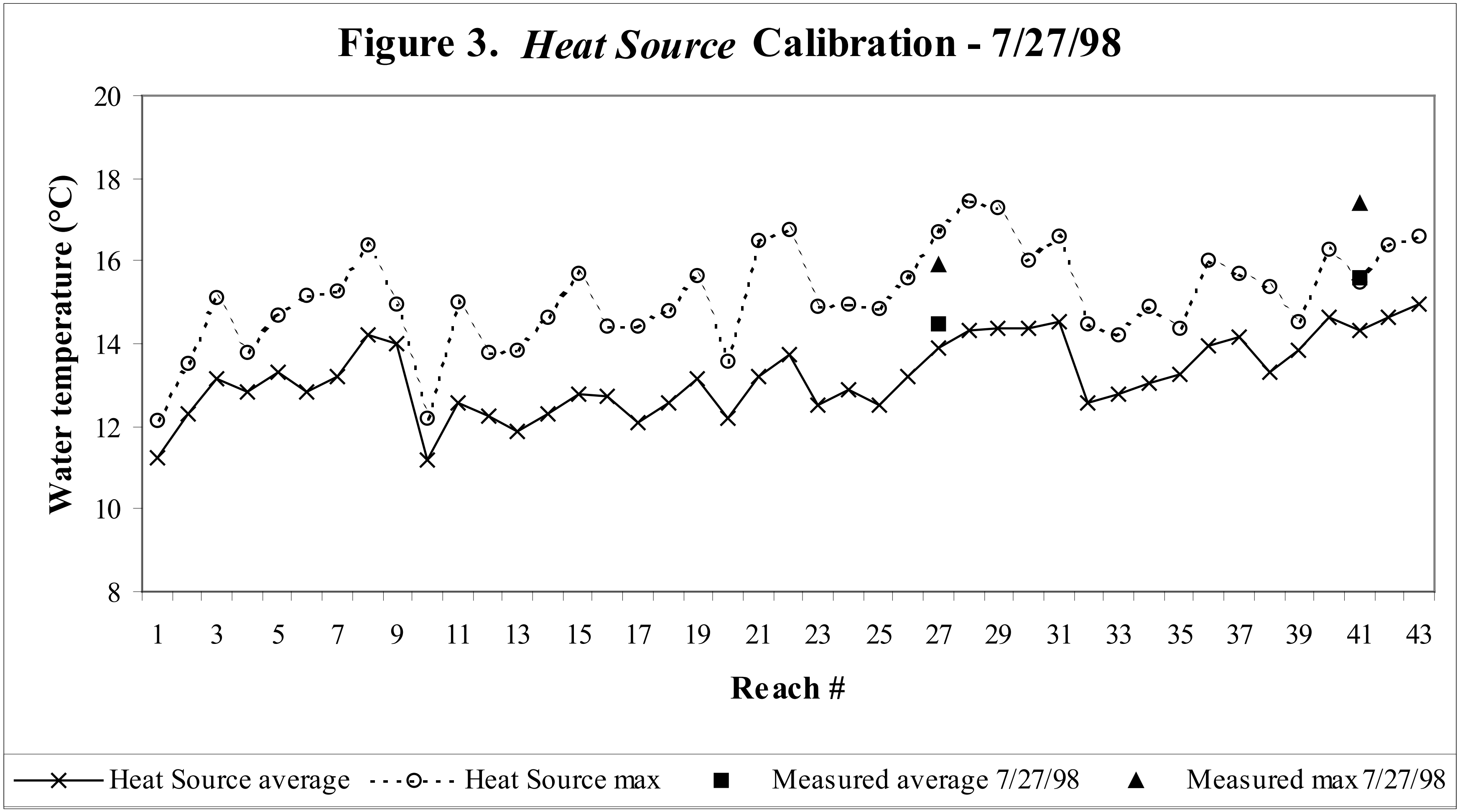

Figure 4. ***Heat Source*** **Prediction – 8/6/99**

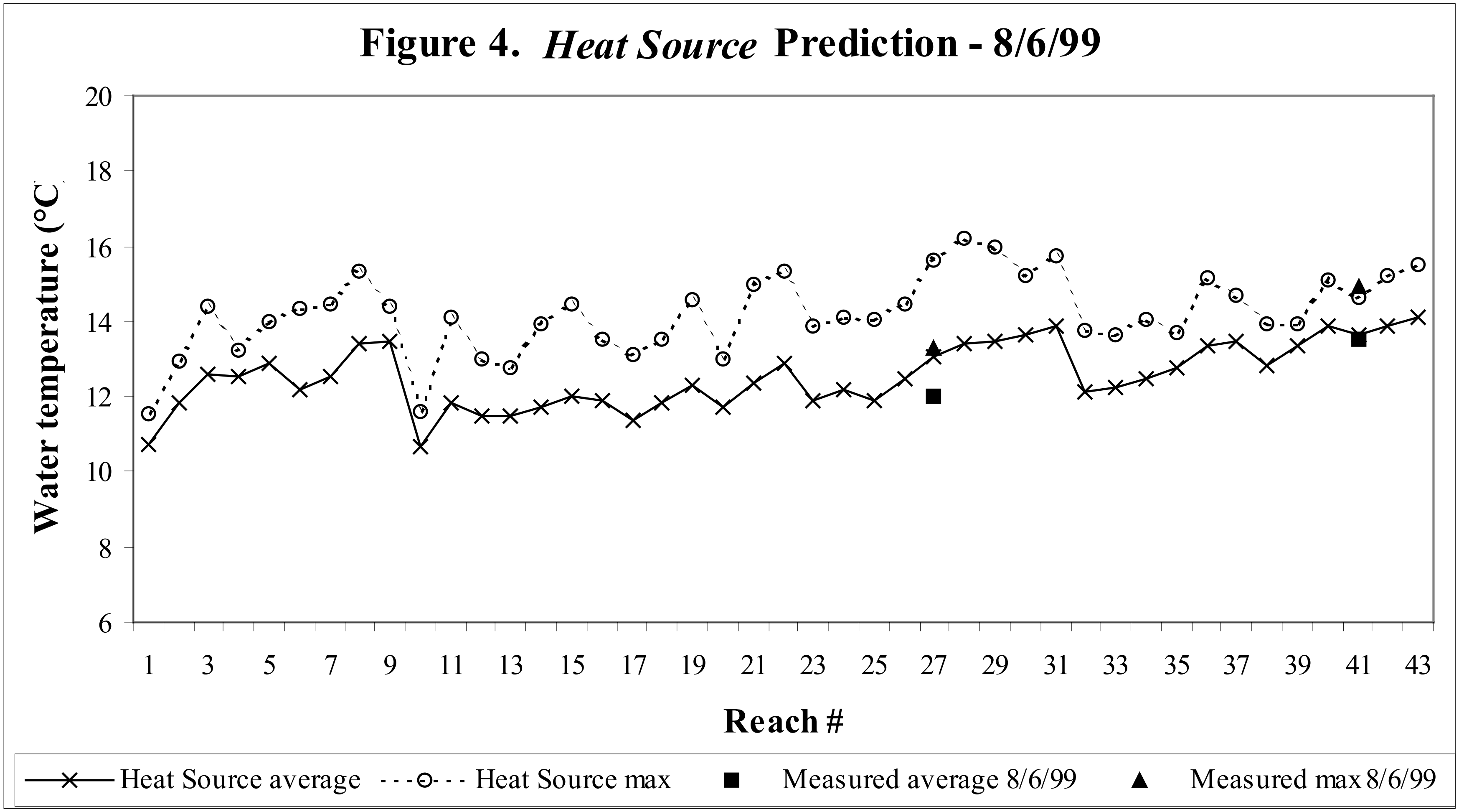

Figure 5. SSTEMP Calibration – 7/27/98

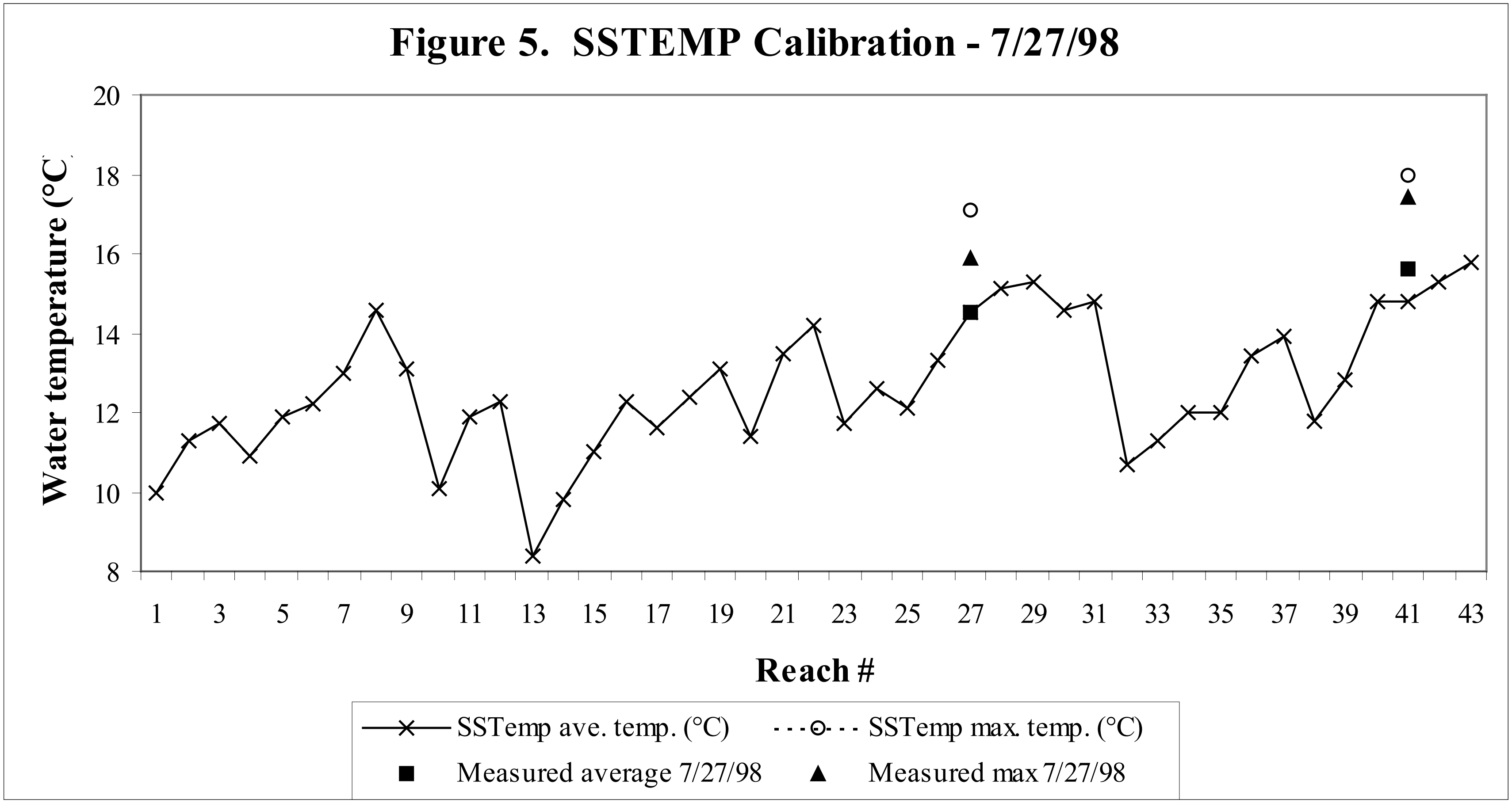

Figure 6. SSTEMP Prediction – 8/6/99

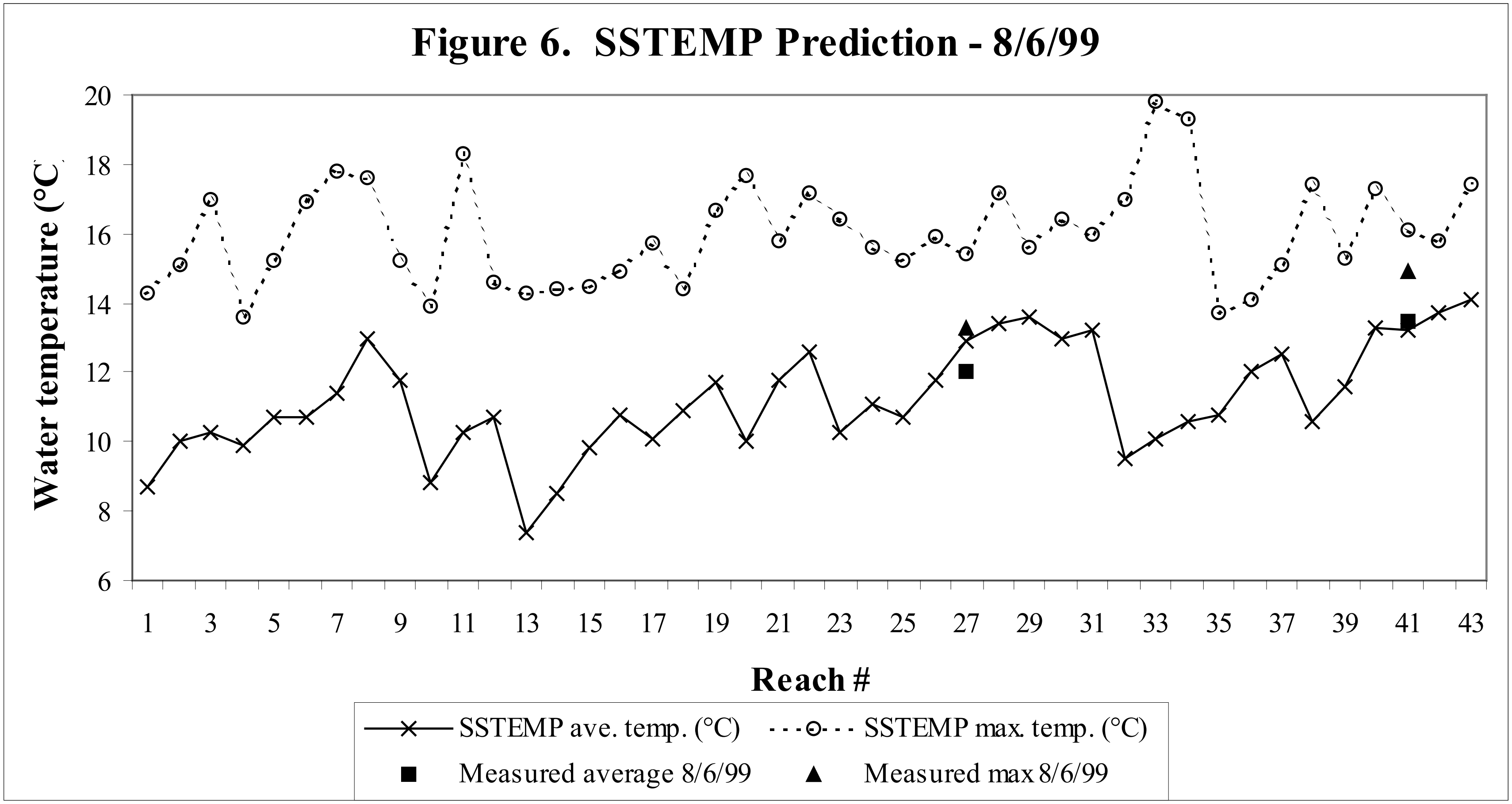

Figure 7. CWE Prediction

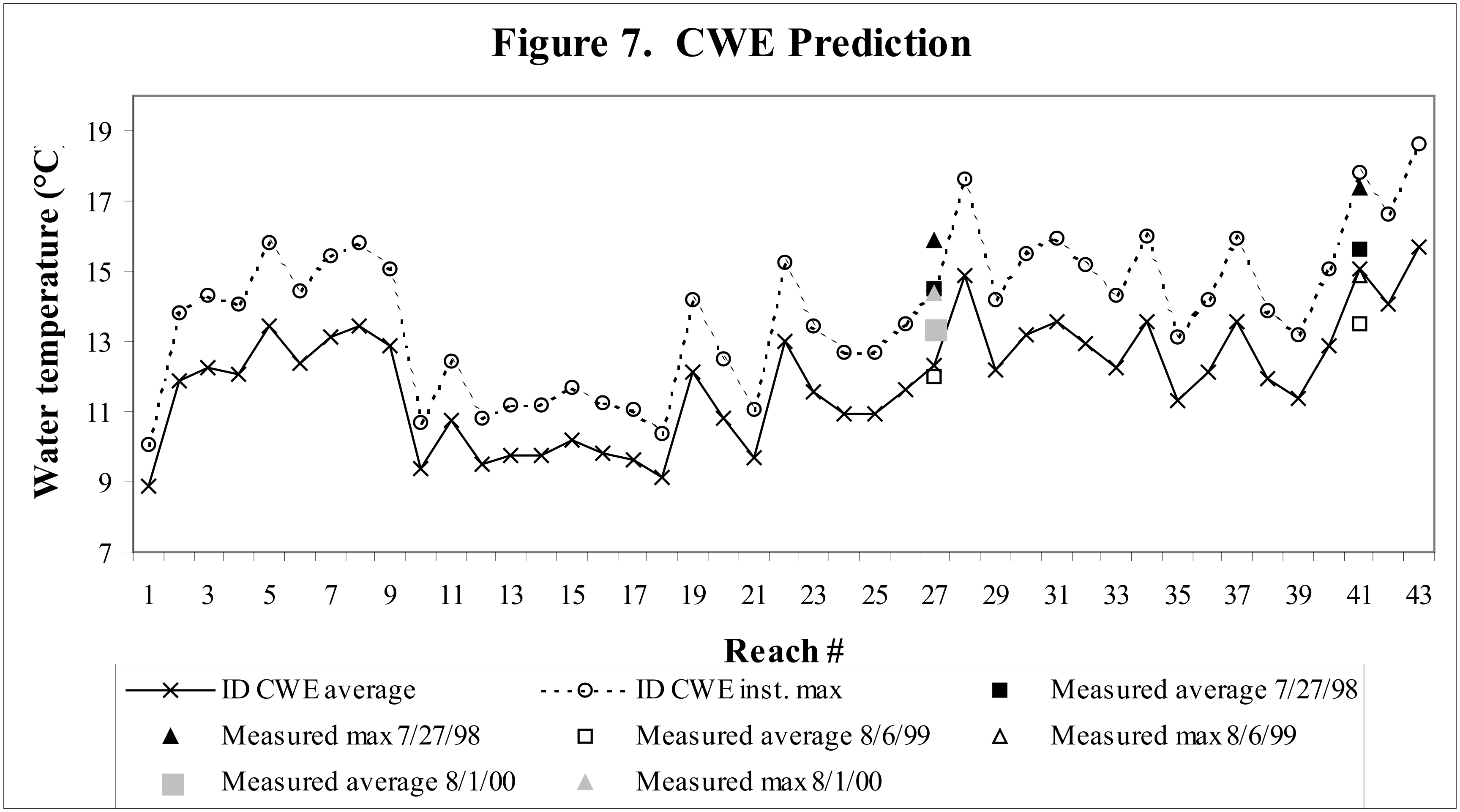

Table 1. *Heat Source* Calibration for 7/27/98 (page 1 of 5)

Cold Springs Creek - *Heat Source* Inputs for 7/27/98 Calibration									
Input parameters									
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	210	130	215	115	120	135	215	170	105
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	586	1,074	534	798	462	736	238	660	1,231
Stream width (m)	1.5	2.0	1.5	2.3	2.7	2.0	2.0	2.0	3.5
Flow volume (cms)	0.0020	0.0085	0.0060	0.0387	0.0728	0.0062	0.0138	0.0165	0.1011
Velocity (m/s)	0.18	0.24	0.18	0.28	0.26	0.19	0.19	0.20	0.38
G/W inflow (cms)	0.0065	0.0202	0.0040	0.0341	0.0069	0.0076	0.0027	0.0049	0.0394
G/W temperature (°C)	9.8	11.1	11.5	12.3	12.8	11.0	11.9	12.5	13.3
Stream depth (m)	0.032	0.060	0.036	0.112	0.115	0.035	0.043	0.053	0.106
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	70%	55%	50%	65%	50%	45%	40%	50%	70%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	17	39	35	35	39	45	40	39	35
Topographic east (°)	17	39	35	35	39	45	40	39	35
Min. air temp. (°C)	17.8	19.1	19.5	20.3	20.8	19.0	19.9	20.5	21.3
Max. air temp. (°C)	21.8	23.1	23.5	24.3	24.8	23.0	23.9	24.5	25.3

Cold Springs Creek - *Heat Source* Inputs for 7/27/98 Calibration									
Input parameters									
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,676	1,448	1,387	1,250	1,167	1,463	1,311	1,210	1,082
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	11.2	12.3	13.2	12.8	13.3	12.8	13.2	14.2	14.0
Max. outflow temp (°C)	12.2	13.5	15.1	13.8	14.7	15.2	15.3	16.4	15.0

Table 1. *Heat Source* Calibration for 7/27/98 (page 2 of 5)

Cold Springs Creek -									
Input parameters									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	290	230	265	225	140	195	215	135	155
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	955	464	491	307	377	460	288	560	369
Stream width (m)	2.0	2.0	3.0	2.0	2.0	2.7	3.2	2.0	2.2

Cold Springs Creek - Input parameters									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Flow volume (cms)	0.0022	0.0049	0.0263	0.0080	0.0067	0.0214	0.0554	0.0031	0.0085
Velocity (m/s)	0.17	0.14	0.15	0.16	0.13	0.15	0.33	0.14	0.13
G/W inflow (cms)	0.0156	0.0036	0.0038	0.0040	0.0027	0.0038	0.0016	0.0054	0.0033
G/W temperature (°C)	9.8	10.0	10.6	10.2	10.2	10.6	11.0	10.1	10.9
Stream depth (m)	0.053	0.031	0.065	0.039	0.036	0.063	0.055	0.030	0.040
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	65%	45%	70%	60%	60%	60%	70%	65%	80%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	29	27	39	29	39	29	35	31	29
Topographic east (°)	29	27	39	29	39	29	35	31	29
Min. air temp. (°C)	17.8	18.0	18.6	18.2	18.2	18.6	19.0	18.1	18.9
Max. air temp. (°C)	21.8	22.0	22.6	22.2	22.2	22.6	23.0	22.1	22.9
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,670	1,637	1,533	1,603	1,603	1,530	1,475	1,615	1,487
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	11.2	12.6	12.2	11.9	12.3	12.8	12.7	12.1	12.6
Max. outflow temp (°C)	12.2	15.0	13.8	13.8	14.6	15.7	14.4	14.4	14.8

Table 1. *Heat Source* Calibration for 7/27/98 (page 3 of 5)

Cold Springs Creek - Input parameters									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	170	265	220	220	160	190	140	120	170
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	663	377	293	1,191	1,309	346	1,087	459	728
Stream width (m)	3.6	2.0	2.2	4.0	2.5	2.7	2.0	3.1	5.2
Flow volume (cms)	0.0688	0.0031	0.0080	0.0886	0.0098	0.0314	0.0040	0.0507	0.1672
Velocity (m/s)	0.32	0.15	0.14	0.37	0.29	0.35	0.28	0.34	0.29
G/W inflow (cms)	0.0107	0.0049	0.0011	0.0231	0.0216	0.0036	0.0116	0.0049	0.0136
G/W temperature (°C)	11.3	10.6	11.3	12.1	10.7	11.7	11.0	12.3	12.9
Stream depth (m)	0.069	0.027	0.030	0.075	0.043	0.038	0.027	0.052	0.121
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	45%	55%	80%	50%	50%	70%	70%	70%	70%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	35	17	22	39	31	39	45	45	45
Topographic east (°)	35	17	22	39	31	39	45	45	45
Min. air temp. (°C)	19.3	18.6	19.3	20.1	18.7	19.7	19.0	20.3	20.9
Max. air temp. (°C)	23.3	22.6	23.3	24.1	22.7	23.7	23.0	24.3	24.9
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%

Cold Springs Creek - Input parameters									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,411	1,536	1,417	1,286	1,524	1,347	1,469	1,247	1,149
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	13.1	12.2	13.2	13.7	12.5	12.9	12.5	13.2	13.9
Max. outflow temp (°C)	15.7	13.6	16.5	16.7	14.9	15.0	14.8	15.6	16.7

Table 1. *Heat Source* Calibration for 7/27/98 (page 4 of 5)

Cold Springs Creek - Input parameters									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	170	165	105	145	185	230	230	210	210
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	605	212	787	810	1,006	549	325	452	847
Stream width (m)	4.5	4.5	4.5	4.5	2.0	2.0	2.5	2.5	2.9
Flow volume (cms)	0.1809	0.1883	0.3298	0.3566	0.0116	0.0084	0.0450	0.0505	0.0643
Velocity (m/s)	0.39	0.33	0.77	0.78	0.44	0.39	0.40	0.43	0.25
G/W inflow (cms)	0.0074	0.0009	0.0269	0.0229	0.0182	0.0069	0.0054	0.0138	0.0091

Cold Springs Creek - Input parameters									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
G/W temperature (°C)	13.4	13.6	13.8	14.1	11.2	11.3	12.2	12.8	13.6
Stream depth (m)	0.107	0.127	0.103	0.108	0.034	0.019	0.051	0.059	0.099
Buffer height (m)	18	18	18	18	12	12	3	18	18
Buffer width (m)	10	10	10	10	7	7	3	10	10
Canopy density	40%	80%	70%	70%	40%	50%	40%	85%	85%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	45	45	45	45	39	29	39	46	46
Topographic east (°)	45	45	45	45	39	29	39	46	46
Min. air temp. (°C)	21.4	21.6	21.8	22.1	19.2	19.3	20.2	20.8	21.6
Max. air temp. (°C)	25.4	25.6	25.8	26.1	23.2	23.3	24.2	24.8	25.6
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,067	1,030	1,000	951	1,426	1,417	1,265	1,158	1,036
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	14.3	14.4	14.3	14.5	12.6	12.8	13.0	13.2	13.9
Max. outflow temp (°C)	17.5	17.3	16.0	16.6	14.5	14.2	14.9	14.4	16.0

Table 1. *Heat Source* Calibration for 7/27/98 (page 5 of 5)

Cold Springs Creek - Input parameters							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115
Stream aspect (°)	210	225	230	240	120	130	170
% bedrock	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	254	549	491	391	229	995	646
Stream width (m)	2.9	2.0	2.0	2.5	5.5	5.5	5.5
Flow volume (cms)	0.0734	0.0076	0.0147	0.0214	0.4761	0.4814	0.4959
Velocity (m/s)	0.28	0.37	0.39	0.29	0.43	0.46	0.43
G/W inflow (cms)	0.0007	0.0071	0.0067	0.0011	0.0053	0.0145	0.0056
G/W temperature (°C)	14.1	12.3	13.2	13.9	14.2	14.5	14.7
Stream depth (m)	0.092	0.020	0.027	0.031	0.201	0.197	0.214
Buffer height (m)	18	18	18	18	18	18	12
Buffer width (m)	10	10	10	10	10	10	7
Canopy density	70%	70%	90%	80%	50%	70%	50%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	54	29	17	42	45	45	11
Topographic east (°)	54	29	17	42	45	45	11
Min. air temp. (°C)	22.1	20.3	21.2	21.9	22.2	22.5	22.7
Max. air temp. (°C)	26.1	24.3	25.2	25.9	26.2	26.5	26.7
Min. humidity	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%

Cold Springs Creek - Input parameters							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Elevation (m)	951	1,250	1,097	981	920	884	838
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	14.2	13.3	13.9	14.6	14.3	14.6	14.9
Max. outflow temp (°C)	15.7	15.4	14.5	16.3	15.5	16.4	16.6

Table 2. ***Heat Source*** **Calibration for 8/6/99 (page 1 of 5)**

Cold Springs Creek - ***Heat Source*** **Inputs for 8/6/99 Prediction** Input parameters									
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	210	130	215	115	120	135	215	170	105
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	586	1,074	534	798	462	736	238	660	1,231
Stream width (m)	1.5	2.0	1.5	2.3	2.7	2.0	2.0	2.0	3.5
Flow volume (cms)	0.0020	0.0085	0.0060	0.0387	0.0728	0.0062	0.0138	0.0165	0.1011
Velocity (m/s)	0.18	0.24	0.18	0.28	0.26	0.19	0.19	0.20	0.38
G/W inflow (cms)	0.0065	0.0202	0.0040	0.0341	0.0069	0.0076	0.0027	0.0049	0.0394
G/W temperature (°C)	9.8	11.1	11.5	12.3	12.8	11.0	11.9	12.5	13.3
Stream depth (m)	0.032	0.060	0.036	0.112	0.115	0.035	0.043	0.053	0.106

Cold Springs Creek - ***Heat Source*** **Inputs for 8/6/99 Prediction**

Input parameters									
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	70%	55%	50%	65%	50%	45%	40%	50%	70%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	17	39	35	35	39	45	40	39	35
Topographic east (°)	17	39	35	35	39	45	40	39	35
Min. air temp. (°C)	17.8	19.1	19.5	20.3	20.8	19.0	19.9	20.5	21.3
Max. air temp. (°C)	21.8	23.1	23.5	24.3	24.8	23.0	23.9	24.5	25.3
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,676	1,448	1,387	1,250	1,167	1,463	1,311	1,210	1,082
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	11.2	12.3	13.2	12.8	13.3	12.8	13.2	14.2	14.0
Max. outflow temp (°C)	12.2	13.5	15.1	13.8	14.7	15.2	15.3	16.4	15.0

Table 2. *Heat Source* Calibration for 8/6/99 (page 2 of 5)

Cold Springs Creek - Input parameters									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	290	230	265	225	140	195	215	135	155
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	955	464	491	307	377	460	288	560	369
Stream width (m)	2.0	2.0	3.0	2.0	2.0	2.7	3.2	2.0	2.2
Flow volume (cms)	0.0022	0.0049	0.0263	0.0080	0.0067	0.0214	0.0554	0.0031	0.0085
Velocity (m/s)	0.17	0.14	0.15	0.16	0.13	0.15	0.33	0.14	0.13
G/W inflow (cms)	0.0156	0.0036	0.0038	0.0040	0.0027	0.0038	0.0016	0.0054	0.0033
G/W temperature (°C)	9.8	10.0	10.6	10.2	10.2	10.6	11.0	10.1	10.9
Stream depth (m)	0.053	0.031	0.065	0.039	0.036	0.063	0.055	0.030	0.040
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	65%	45%	70%	60%	60%	60%	70%	65%	80%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	29	27	39	29	39	29	35	31	29
Topographic east (°)	29	27	39	29	39	29	35	31	29
Min. air temp. (°C)	17.8	18.0	18.6	18.2	18.2	18.6	19.0	18.1	18.9
Max. air temp. (°C)	21.8	22.0	22.6	22.2	22.2	22.6	23.0	22.1	22.9
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%

Cold Springs Creek - Input parameters									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,670	1,637	1,533	1,603	1,603	1,530	1,475	1,615	1,487
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	11.2	12.6	12.2	11.9	12.3	12.8	12.7	12.1	12.6
Max. outflow temp (°C)	12.2	15.0	13.8	13.8	14.6	15.7	14.4	14.4	14.8

Table 2. *Heat Source* Calibration for 8/6/99 (page 3 of 5)

Cold Springs Creek - Input parameters									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	170	265	220	220	160	190	140	120	170
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	663	377	293	1,191	1,309	346	1,087	459	728
Stream width (m)	3.6	2.0	2.2	4.0	2.5	2.7	2.0	3.1	5.2
Flow volume (cms)	0.0688	0.0031	0.0080	0.0886	0.0098	0.0314	0.0040	0.0507	0.1672
Velocity (m/s)	0.32	0.15	0.14	0.37	0.29	0.35	0.28	0.34	0.29
G/W inflow (cms)	0.0107	0.0049	0.0011	0.0231	0.0216	0.0036	0.0116	0.0049	0.0136

Cold Springs Creek - Input parameters									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
G/W temperature (°C)	11.3	10.6	11.3	12.1	10.7	11.7	11.0	12.3	12.9
Stream depth (m)	0.069	0.027	0.030	0.075	0.043	0.038	0.027	0.052	0.121
Buffer height (m)	18	18	18	18	18	18	18	18	18
Buffer width (m)	10	10	10	10	10	10	10	10	10
Canopy density	45%	55%	80%	50%	50%	70%	70%	70%	70%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	35	17	22	39	31	39	45	45	45
Topographic east (°)	35	17	22	39	31	39	45	45	45
Min. air temp. (°C)	19.3	18.6	19.3	20.1	18.7	19.7	19.0	20.3	20.9
Max. air temp. (°C)	23.3	22.6	23.3	24.1	22.7	23.7	23.0	24.3	24.9
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,411	1,536	1,417	1,286	1,524	1,347	1,469	1,247	1,149
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	13.1	12.2	13.2	13.7	12.5	12.9	12.5	13.2	13.9
Max. outflow temp (°C)	15.7	13.6	16.5	16.7	14.9	15.0	14.8	15.6	16.7

Table 2. *Heat Source* Calibration for 8/6/99 (page 4 of 5)

Cold Springs Creek - Input parameters									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115	115	115
Stream aspect (°)	170	165	105	145	185	230	230	210	210
% bedrock	25%	25%	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	605	212	787	810	1,006	549	325	452	847
Stream width (m)	4.5	4.5	4.5	4.5	2.0	2.0	2.5	2.5	2.9
Flow volume (cms)	0.1809	0.1883	0.3298	0.3566	0.0116	0.0084	0.0450	0.0505	0.0643
Velocity (m/s)	0.39	0.33	0.77	0.78	0.44	0.39	0.40	0.43	0.25
G/W inflow (cms)	0.0074	0.0009	0.0269	0.0229	0.0182	0.0069	0.0054	0.0138	0.0091
G/W temperature (°C)	13.4	13.6	13.8	14.1	11.2	11.3	12.2	12.8	13.6
Stream depth (m)	0.107	0.127	0.103	0.108	0.034	0.019	0.051	0.059	0.099
Buffer height (m)	18	18	18	18	12	12	3	18	18
Buffer width (m)	10	10	10	10	7	7	3	10	10
Canopy density	40%	80%	70%	70%	40%	50%	40%	85%	85%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	45	45	45	45	39	29	39	46	46
Topographic east (°)	45	45	45	45	39	29	39	46	46
Min. air temp. (°C)	21.4	21.6	21.8	22.1	19.2	19.3	20.2	20.8	21.6
Max. air temp. (°C)	25.4	25.6	25.8	26.1	23.2	23.3	24.2	24.8	25.6
Min. humidity	45%	45%	45%	45%	45%	45%	45%	45%	45%

Cold Springs Creek - Input parameters									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Max. humidity	85%	85%	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	1,067	1,030	1,000	951	1,426	1,417	1,265	1,158	1,036
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	14.3	14.4	14.3	14.5	12.6	12.8	13.0	13.2	13.9
Max. outflow temp (°C)	17.5	17.3	16.0	16.6	14.5	14.2	14.9	14.4	16.0

Table 2. *Heat Source* Calibration for 8/6/99 (page 5 of 5)

Cold Springs Creek - Input parameters							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Latitude (°)	47	47	47	47	47	47	47
Longitude (°)	115	115	115	115	115	115	115
Stream aspect (°)	210	225	230	240	120	130	170
% bedrock	25%	25%	25%	25%	25%	25%	25%
Reach length (m)	254	549	491	391	229	995	646
Stream width (m)	2.9	2.0	2.0	2.5	5.5	5.5	5.5
Flow volume (cms)	0.0734	0.0076	0.0147	0.0214	0.4761	0.4814	0.4959
Velocity (m/s)	0.28	0.37	0.39	0.29	0.43	0.46	0.43
G/W inflow (cms)	0.0007	0.0071	0.0067	0.0011	0.0053	0.0145	0.0056
G/W temperature (°C)	14.1	12.3	13.2	13.9	14.2	14.5	14.7

Cold Springs Creek - Input parameters							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Stream depth (m)	0.092	0.020	0.027	0.031	0.201	0.197	0.214
Buffer height (m)	18	18	18	18	18	18	12
Buffer width (m)	10	10	10	10	10	10	7
Canopy density	70%	70%	90%	80%	50%	70%	50%
Distance to stream (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incision (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tree overhang (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topographic west (°)	54	29	17	42	45	45	11
Topographic east (°)	54	29	17	42	45	45	11
Min. air temp. (°C)	22.1	20.3	21.2	21.9	22.2	22.5	22.7
Max. air temp. (°C)	26.1	24.3	25.2	25.9	26.2	26.5	26.7
Min. humidity	45%	45%	45%	45%	45%	45%	45%
Max. humidity	85%	85%	85%	85%	85%	85%	85%
Elevation (m)	951	1,250	1,097	981	920	884	838
Wind speed (m/s)	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Ave. outflow temp (°C)	14.2	13.3	13.9	14.6	14.3	14.6	14.9
Max. outflow temp (°C)	15.7	15.4	14.5	16.3	15.5	16.4	16.6

Table 3. SSTemp Calibration for 7/27/98 (page 1 of 5)

Cold Springs Creek -	SSTemp Inputs for 7/27/98								
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Inflow volume (cfs)	0.07	0.30	0.21	1.37	2.57	0.22	0.49	0.58	3.57
Inflow temp. (°C)	3.8	10.0	5.5	11.4	10.9	5.0	12.2	13.0	12.5
Outflow volume (cfs)	0.30	1.01	0.35	2.57	2.82	0.49	0.58	0.76	4.96
G/W temperature (°C)	3.8	5.1	5.5	6.3	6.8	5.0	5.9	6.5	7.3
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.364	0.667	0.332	0.496	0.287	0.457	0.148	0.410	0.765
Upstream elev. (ft)	5,800	5,200	4,800	4,300	3,920	5,200	4,400	4,200	3,740
Downstream elev. (ft)	5,200	4,300	4,300	3,900	3,740	4,400	4,200	3,740	3,360
Width A term (s/ft^2)	6.89	7.13	6.34	6.59	7.26	8.08	7.43	7.11	8.59
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.183
Azimuth (° from south)	30	-50	35	-65	-60	-45	35	-10	-75
Topographic west (°)	17	39	35	35	39	45	40	39	35
Topographic east (°)	17	39	35	35	39	45	40	39	35
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	70%	55%	50%	65%	50%	45%	40%	50%	70%

Cold Springs Creek -	SSTemp Inputs for 7/27/98								
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Canopy density east	70%	55%	50%	65%	50%	45%	40%	50%	70%
Average air temp. (°C)	19.3	20.6	21.0	21.8	22.3	20.5	21.4	22.0	22.8
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	3.8	5.1	5.5	6.3	6.8	5.0	5.9	6.5	7.3
Ave. wetted width (ft)	4.9	6.6	4.9	7.5	8.9	6.6	6.6	6.6	11.5
Calculated depth (ft)	0.11	0.20	0.12	0.37	0.38	0.12	0.14	0.17	0.35
SSTemp ave. temp. (°C)	10.0	11.3	11.7	10.9	11.9	12.2	13.0	14.6	13.1
SSTemp max. temp. (°C)									

Table 3. SSTemp Calibration for 7/27/98 (page 2 of 5)

Cold Springs Creek -									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Inflow volume (cfs)	0.08	0.17	0.93	0.28	0.24	0.76	1.96	0.11	0.30
Inflow temp. (°C)	3.8	4.0	10.7	4.2	4.2	9.0	11.7	4.1	11.6
Outflow volume (cfs)	0.63	0.30	1.06	0.42	0.33	0.89	2.01	0.30	0.42
G/W temperature (°C)	3.8	4.0	4.6	4.2	4.2	4.6	5.0	4.1	4.9
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.593	0.288	0.305	0.191	0.234	0.286	0.179	0.348	0.229

Cold Springs Creek -									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Upstream elev. (ft)	5,800	5,600	5,140	5,400	5,400	5,120	4,920	5,600	5,000
Downstream elev. (ft)	5,140	5,140	4,920	5,120	5,120	4,920	4,760	5,000	4,760
Width A term (s/ft^2)	8.08	8.75	9.85	8.08	8.43	9.21	9.15	9.00	8.86
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.389	0.389	0.389	0.389	0.389	0.389	0.183	0.389	0.389
Azimuth (° from south)	-70	50	85	45	-40	15	35	-45	-25
Topographic west (°)	29	27	39	29	39	29	35	31	29
Topographic east (°)	29	27	39	29	39	29	35	31	29
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	65%	45%	70%	60%	60%	60%	70%	65%	80%
Canopy density east	65%	45%	70%	60%	60%	60%	70%	65%	80%
Average air temp. (°C)	19.3	19.5	20.1	19.7	19.7	20.1	20.5	19.6	20.4
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	3.8	4.0	4.6	4.2	4.2	4.6	5.0	4.1	4.9
Ave. wetted width (ft)	6.6	6.6	9.8	6.6	6.6	8.9	10.5	6.6	7.2
Calculated depth (ft)	0.17	0.10	0.21	0.13	0.12	0.21	0.18	0.10	0.13
SSTemp ave. temp. (°C)	10.1	11.9	12.3	8.4	9.8	11.0	12.3	11.6	12.4
SSTemp max. temp. (°C)									

Table 3. SSTemp Calibration for 7/27/98 (page 3 of 5)

Cold Springs Creek -									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Inflow volume (cfs)	2.43	0.11	0.28	3.13	0.35	1.11	0.14	1.79	5.91
Inflow temp. (°C)	12.3	4.6	11.4	13.1	4.7	11.7	5.0	12.4	13.9
Outflow volume (cfs)	2.81	0.28	0.32	3.94	1.11	1.24	0.55	1.96	6.39
G/W temperature (°C)	5.3	4.6	5.3	6.1	4.7	5.7	5.0	6.3	6.9
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.412	0.234	0.182	0.740	0.813	0.215	0.675	0.285	0.452
Upstream elev. (ft)	4,760	5,280	4,800	4,500	5,400	4,600	5,400	4,240	3,940
Downstream elev. (ft)	4,500	4,800	4,500	3,940	4,600	4,240	4,240	3,940	3,600
Width A term (s/ft^2)	9.74	9.09	9.17	10.19	8.74	8.58	8.11	8.97	11.86
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.183	0.389	0.389	0.183	0.183	0.183	0.183	0.183	0.320
Azimuth (° from south)	-10	85	40	40	-20	10	-40	-60	-10
Topographic west (°)	35	17	22	39	31	39	45	45	45
Topographic east (°)	35	17	22	39	31	39	45	45	45
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	45%	55%	80%	50%	50%	70%	70%	70%	70%
Canopy density east	45%	55%	80%	50%	50%	70%	70%	70%	70%
Average air temp. (°C)	20.8	20.1	20.8	21.6	20.2	21.2	20.5	21.8	22.4

Cold Springs Creek -									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	5.3	4.6	5.3	6.1	4.7	5.7	5.0	6.3	6.9
Ave. wetted width (ft)	11.8	6.6	7.2	13.1	8.2	8.9	6.6	10.2	17.1
Calculated depth (ft)	0.23	0.09	0.10	0.25	0.14	0.12	0.09	0.17	0.40
SSTemp ave. temp. (°C)	13.1	11.4	13.5	14.2	11.7	12.6	12.1	13.3	14.5
SSTemp max. temp. (°C)									17.1

Table 3. SSTemp Calibration for 7/27/98 (page 4 of 5)

Cold Springs Creek -									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Inflow volume (cfs)	6.39	6.65	11.65	12.59	0.41	0.29	1.59	1.78	2.27
Inflow temp. (°C)	14.5	15.1	14.4	14.6	5.2	5.3	10.9	12.0	12.0
Outflow volume (cfs)	6.65	6.68	12.59	13.40	1.05	0.54	1.78	2.27	2.59
G/W temperature (°C)	7.4	7.6	7.8	8.1	5.2	5.3	6.2	6.8	7.6
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.376	0.132	0.489	0.503	0.625	0.341	0.202	0.281	0.526
Upstream elev. (ft)	3,600	3,400	3,360	3,200	5,060	5,000	4,300	4,000	3,600
Downstream elev. (ft)	3,400	3,360	3,200	3,040	4,300	4,300	4,000	3,600	3,200
Width A term (s/ft^2)	10.15	10.10	8.96	8.84	6.98	7.81	7.39	7.12	7.96
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.183	0.183	0.071	0.071	0.114	0.114	0.183	0.183	0.320

Cold Springs Creek -									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Azimuth (° from south)	-10	-15	-75	-35	5	50	50	30	30
Topographic west (°)	45	45	45	45	39	29	39	46	46
Topographic east (°)	45	45	45	45	39	29	39	46	46
Buffer height west (ft)	60	60	60	60	40	40	10	60	60
Buffer height east (ft)	60	60	60	60	40	40	10	60	60
Buffer crown west (ft)	30	30	30	30	20	20	5	30	30
Buffer crown east (ft)	30	30	30	30	20	20	5	30	30
Buffer offset west (ft)	15	15	15	15	10	10	3	15	15
Buffer offset east (ft)	15	15	15	15	10	10	3	15	15
Canopy density west	40%	80%	70%	70%	40%	50%	40%	85%	85%
Canopy density east	40%	80%	70%	70%	40%	50%	40%	85%	85%
Average air temp. (°C)	22.9	23.1	23.3	23.6	20.7	20.8	21.7	22.3	23.1
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	7.4	7.6	7.8	8.1	5.2	5.3	6.2	6.8	7.6
Ave. wetted width (ft)	14.8	14.8	14.8	14.8	6.6	6.6	8.2	8.2	9.5
Calculated depth (ft)	0.35	0.42	0.34	0.35	0.11	0.06	0.17	0.19	0.33
SSTemp ave. temp. (°C)	15.1	15.3	14.6	14.8	10.7	11.3	12.0	12.0	13.4
SSTemp max. temp. (°C)									

Table 3. SSTemp Calibration for 7/27/98 (page 5 of 5)

Cold Springs Creek -							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Date	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98	7/27/98
Inflow volume (cfs)	2.59	0.27	0.52	0.76	16.81	17.00	17.51
Inflow temp. (°C)	13.4	6.3	11.8	12.8	14.7	14.8	15.3
Outflow volume (cfs)	2.62	0.52	0.76	0.80	17.00	17.51	17.71
G/W temperature (°C)	8.1	6.3	7.2	7.9	8.2	8.5	8.7
Latitude (°)	47	47	47	47	47	47	47
Reach length (mi)	0.158	0.341	0.305	0.243	0.142	0.618	0.401
Upstream elev. (ft)	3,200	4,400	3,800	3,400	3,040	3,000	2,800
Downstream elev. (ft)	3,040	3,800	3,400	3,040	3,000	2,800	2,700
Width A term (s/ft^2)	7.86	7.90	7.18	8.63	10.25	10.21	10.16
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.320	0.114	0.114	0.183	0.183	0.183	0.183
Azimuth (° from south)	30	45	50	60	-60	-50	-10
Topographic west (°)	54	29	17	42	45	45	11
Topographic east (°)	54	29	17	42	45	45	11
Buffer height west (ft)	60	60	60	60	60	60	40
Buffer height east (ft)	60	60	60	60	60	60	40
Buffer crown west (ft)	30	30	30	30	30	30	20
Buffer crown east (ft)	30	30	30	30	30	30	20
Buffer offset west (ft)	15	15	15	15	15	15	10
Buffer offset east (ft)	15	15	15	15	15	15	10
Canopy density west	70%	70%	90%	80%	50%	70%	50%
Canopy density east	70%	70%	90%	80%	50%	70%	50%
Average air temp. (°C)	23.6	21.8	22.7	23.4	23.7	24.0	24.2
Average humidity	65%	65%	65%	65%	65%	65%	65%

Cold Springs Creek -							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	8.1	6.3	7.2	7.9	8.2	8.5	8.7
Ave. wetted width (ft)	9.5	6.6	6.6	8.2	18.0	18.0	18.0
Calculated depth (ft)	0.30	0.07	0.09	0.10	0.66	0.65	0.70
SSTemp ave. temp. (°C)	13.9	11.8	12.8	14.8	14.8	15.3	15.8
SSTemp max. temp. (°C)					18.0		

Table 4. SSTemp Calibration for 8/6/99 (page 1 of 5)

Cold Springs Creek -	SSTemp Inputs for 8/6/99 Prediction								
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Date	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99
Inflow volume (cfs)	0.08	0.35	0.25	1.61	3.03	0.26	0.57	0.69	4.20
Inflow temp. (°C)	3.8	8.7	5.5	10.1	9.9	5.0	10.7	11.4	11.2
Outflow volume (cfs)	0.35	1.19	0.41	3.03	3.31	0.57	0.69	0.89	5.84
G/W temperature (°C)	3.8	5.1	5.5	6.3	6.8	5.0	5.9	6.5	7.3
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.364	0.667	0.332	0.496	0.287	0.457	0.148	0.410	0.765
Upstream elev. (ft)	5,800	5,200	4,800	4,300	3,920	5,200	4,400	4,200	3,740
Downstream elev. (ft)	5,200	4,300	4,300	3,900	3,740	4,400	4,200	3,740	3,360
Width A term (s/ft^2)	6.67	6.91	6.13	6.38	7.03	7.82	7.20	6.88	8.31
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.317	0.317	0.317	0.317	0.317	0.317	0.317	0.317	0.181
Azimuth (° from south)	30	-50	35	-65	-60	-45	35	-10	-75

Cold Springs Creek -	SSTemp Inputs for 8/6/99 Prediction								
Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Topographic west (°)	17	39	35	35	39	45	40	39	35
Topographic east (°)	17	39	35	35	39	45	40	39	35
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	70%	55%	50%	65%	50%	45%	40%	50%	70%
Canopy density east	70%	55%	50%	65%	50%	45%	40%	50%	70%
Average air temp. (°C)	17.8	19.1	19.5	20.3	20.8	19.0	19.9	20.5	21.3
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	3.8	5.1	5.5	6.3	6.8	5.0	5.9	6.5	7.3
Ave. wetted width (ft)	4.9	6.6	4.9	7.5	8.9	6.6	6.6	6.6	11.5
Calculated depth (ft)	0.12	0.21	0.13	0.40	0.42	0.13	0.15	0.19	0.38
SSTEMP ave. temp. (°C)	8.7	10.0	10.3	9.9	10.7	10.7	11.4	13.0	11.8
SSTEMP max. temp. (°C)	14.3	15.1	17.0	13.6	15.2	16.9	17.8	17.6	15.2

Table 4. SSTemp Calibration for 8/6/99 (page 2 of 5)

Cold Springs Creek -									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Date	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99
Inflow volume (cfs)	0.09	0.20	1.09	0.33	0.28	0.89	2.30	0.13	0.35
Inflow temp. (°C)	3.8	4.0	9.3	4.2	4.2	7.9	10.3	4.1	10.1
Outflow volume (cfs)	0.74	0.35	1.25	0.50	0.39	1.05	2.37	0.35	0.49
G/W temperature (°C)	3.8	4.0	4.6	4.2	4.2	4.6	5.0	4.1	4.9
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.593	0.288	0.305	0.191	0.234	0.286	0.179	0.348	0.229
Upstream elev. (ft)	5,800	5,600	5,140	5,400	5,400	5,120	4,920	5,600	5,000
Downstream elev. (ft)	5,140	5,140	4,920	5,120	5,120	4,920	4,760	5,000	4,760
Width A term (s/ft^2)	7.82	8.47	9.53	7.82	8.16	8.91	8.86	8.72	8.57
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.385	0.385	0.385	0.385	0.385	0.385	0.181	0.385	0.385
Azimuth (° from south)	-70	50	85	45	-40	15	35	-45	-25
Topographic west (°)	29	27	39	29	39	29	35	31	29
Topographic east (°)	29	27	39	29	39	29	35	31	29
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	65%	45%	70%	60%	60%	60%	70%	65%	80%
Canopy density east	65%	45%	70%	60%	60%	60%	70%	65%	80%
Average air temp. (°C)	17.8	18.0	18.6	18.2	18.2	18.6	19.0	18.1	18.9

Cold Springs Creek -									
Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	3.8	4.0	4.6	4.2	4.2	4.6	5.0	4.1	4.9
Ave. wetted width (ft)	6.6	6.6	9.8	6.6	6.6	8.9	10.5	6.6	7.2
Calculated depth (ft)	0.19	0.11	0.23	0.14	0.13	0.23	0.20	0.11	0.14
SSTEMP ave. temp. (°C)	8.8	10.3	10.7	7.4	8.5	9.8	10.8	10.1	10.9
SSTEMP max. temp. (°C)	13.9	18.3	14.6	14.3	14.4	14.5	14.9	15.7	14.4

Table 4. SSTemp Calibration for 8/6/99 (page 3 of 5)

Cold Springs Creek -									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Date	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99
Inflow volume (cfs)	2.86	0.13	0.33	3.68	0.41	1.31	0.17	2.10	6.95
Inflow temp. (°C)	10.8	4.6	10.0	11.7	4.7	10.3	5.0	11.0	12.3
Outflow volume (cfs)	3.30	0.33	0.38	4.64	1.31	1.46	0.65	2.31	7.51
G/W temperature (°C)	5.3	4.6	5.3	6.1	4.7	5.7	5.0	6.3	6.9
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.412	0.234	0.182	0.740	0.813	0.215	0.675	0.285	0.452
Upstream elev. (ft)	4,760	5,280	4,800	4,500	5,400	4,600	5,400	4,240	3,940
Downstream elev. (ft)	4,500	4,800	4,500	3,940	4,600	4,240	4,240	3,940	3,600
Width A term (s/ft^2)	9.43	8.80	8.88	9.87	8.46	8.30	7.85	8.68	11.48
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.181	0.385	0.385	0.181	0.181	0.181	0.181	0.181	0.317

Cold Springs Creek -									
Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Azimuth (° from south)	-10	85	40	40	-20	10	-40	-60	-10
Topographic west (°)	35	17	22	39	31	39	45	45	45
Topographic east (°)	35	17	22	39	31	39	45	45	45
Buffer height west (ft)	60	60	60	60	60	60	60	60	60
Buffer height east (ft)	60	60	60	60	60	60	60	60	60
Buffer crown west (ft)	30	30	30	30	30	30	30	30	30
Buffer crown east (ft)	30	30	30	30	30	30	30	30	30
Buffer offset west (ft)	15	15	15	15	15	15	15	15	15
Buffer offset east (ft)	15	15	15	15	15	15	15	15	15
Canopy density west	45%	55%	80%	50%	50%	70%	70%	70%	70%
Canopy density east	45%	55%	80%	50%	50%	70%	70%	70%	70%
Average air temp. (°C)	19.3	18.6	19.3	20.1	18.7	19.7	19.0	20.3	20.9
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	5.3	4.6	5.3	6.1	4.7	5.7	5.0	6.3	6.9
Ave. wetted width (ft)	11.8	6.6	7.2	13.1	8.2	8.9	6.6	10.2	17.1
Calculated depth (ft)	0.25	0.10	0.11	0.27	0.16	0.13	0.10	0.19	0.43
SSTEMP ave. temp. (°C)	11.7	10.0	11.8	12.6	10.3	11.1	10.7	11.8	12.9
SSTEMP max. temp. (°C)	16.7	17.7	15.8	17.2	16.4	15.6	15.2	15.9	15.4

Table 4. SSTemp Calibration for 8/6/99 (page 4 of 5)

Cold Springs Creek -									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Date	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99
Inflow volume (cfs)	7.51	7.82	13.70	14.82	0.48	0.35	1.87	2.10	2.67
Inflow temp. (°C)	12.9	13.4	12.8	13.0	5.2	5.3	9.7	10.6	10.8
Outflow volume (cfs)	7.82	7.86	14.82	15.77	1.24	0.63	2.10	2.67	3.05
G/W temperature (°C)	7.4	7.6	7.8	8.1	5.2	5.3	6.2	6.8	7.6
Latitude (°)	47	47	47	47	47	47	47	47	47
Reach length (mi)	0.376	0.132	0.489	0.503	0.625	0.341	0.202	0.281	0.526
Upstream elev. (ft)	3,600	3,400	3,360	3,200	5,060	5,000	4,300	4,000	3,600
Downstream elev. (ft)	3,400	3,360	3,200	3,040	4,300	4,300	4,000	3,600	3,200
Width A term (s/ft^2)	9.82	9.78	8.68	8.55	6.76	7.56	7.15	6.89	7.71
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.181	0.181	0.070	0.070	0.113	0.113	0.181	0.181	0.317
Azimuth (° from south)	-10	-15	-75	-35	5	50	50	30	30
Topographic west (°)	45	45	45	45	39	29	39	46	46
Topographic east (°)	45	45	45	45	39	29	39	46	46
Buffer height west (ft)	60	60	60	60	40	40	10	60	60
Buffer height east (ft)	60	60	60	60	40	40	10	60	60
Buffer crown west (ft)	30	30	30	30	20	20	5	30	30
Buffer crown east (ft)	30	30	30	30	20	20	5	30	30
Buffer offset west (ft)	15	15	15	15	10	10	3	15	15
Buffer offset east (ft)	15	15	15	15	10	10	3	15	15
Canopy density west	40%	80%	70%	70%	40%	50%	40%	85%	85%
Canopy density east	40%	80%	70%	70%	40%	50%	40%	85%	85%
Average air temp. (°C)	21.4	21.6	21.8	22.1	19.2	19.3	20.2	20.8	21.6

Cold Springs Creek -									
Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice
Average humidity	65%	65%	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	7.4	7.6	7.8	8.1	5.2	5.3	6.2	6.8	7.6
Ave. wetted width (ft)	14.8	14.8	14.8	14.8	6.6	6.6	8.2	8.2	9.5
Calculated depth (ft)	0.38	0.46	0.37	0.39	0.12	0.07	0.18	0.21	0.36
SSTEMP ave. temp. (°C)	13.4	13.6	13.0	13.2	9.5	10.1	10.6	10.8	12.0
SSTEMP max. temp. (°C)	17.2	15.6	16.4	16.0	17.0	19.8	19.3	13.7	14.1

Table 4. SSTemp Calibration for 8/6/99 (page 5 of 5)

Cold Springs Creek -							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Date	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99	8/6/99
Inflow volume (cfs)	3.05	0.32	0.61	0.89	19.78	20.00	20.60
Inflow temp. (°C)	12.0	6.3	10.6	11.6	13.1	13.2	13.7
Outflow volume (cfs)	3.08	0.61	0.89	0.94	20.00	20.60	20.84
G/W temperature (°C)	8.1	6.3	7.2	7.9	8.2	8.5	8.7
Latitude (°)	47	47	47	47	47	47	47
Reach length (mi)	0.158	0.341	0.305	0.243	0.142	0.618	0.401
Upstream elev. (ft)	3,200	4,400	3,800	3,400	3,040	3,000	2,800
Downstream elev. (ft)	3,040	3,800	3,400	3,040	3,000	2,800	2,700
Width A term (s/ft^2)	7.60	7.65	6.95	8.35	9.92	9.88	9.84
B term (W = A Q^B)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Manning's n (wetted)	0.317	0.113	0.113	0.181	0.181	0.181	0.181
Azimuth (° from south)	30	45	50	60	-60	-50	-10

Cold Springs Creek -							
Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Topographic west (°)	54	29	17	42	45	45	11
Topographic east (°)	54	29	17	42	45	45	11
Buffer height west (ft)	60	60	60	60	60	60	40
Buffer height east (ft)	60	60	60	60	60	60	40
Buffer crown west (ft)	30	30	30	30	30	30	20
Buffer crown east (ft)	30	30	30	30	30	30	20
Buffer offset west (ft)	15	15	15	15	15	15	10
Buffer offset east (ft)	15	15	15	15	15	15	10
Canopy density west	70%	70%	90%	80%	50%	70%	50%
Canopy density east	70%	70%	90%	80%	50%	70%	50%
Average air temp. (°C)	22.1	20.3	21.2	21.9	22.2	22.5	22.7
Average humidity	65%	65%	65%	65%	65%	65%	65%
Wind speed (mph)	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ground temp. (°C)	8.1	6.3	7.2	7.9	8.2	8.5	8.7
Ave. wetted width (ft)	9.5	6.6	6.6	8.2	18.0	18.0	18.0
Calculated depth (ft)	0.33	0.07	0.10	0.11	0.72	0.71	0.77
SSTEMP ave. temp. (°C)	12.5	10.6	11.6	13.3	13.2	13.7	14.1
SSTEMP max. temp. (°C)	15.1	17.4	15.3	17.3	16.1	15.8	17.4

Table 5. CWE Prediction

Cold Springs Creek - CWE Prediction

Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Downstream elev. (ft)	5,200	4,300	4,300	3,900	3,740	4,400	4,200	3,740	3,360
Canopy density	70%	55%	50%	65%	50%	45%	40%	50%	70%
Ave. outflow temp. (°C)	8.9	11.9	12.2	12.0	13.4	12.4	13.2	13.4	12.9
Max. outflow temp. (°C)	10.1	13.8	14.3	14.0	15.8	14.5	15.4	15.8	15.1

Reach #	10	11	12	13	14	15	16	17	18
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool	Upper Cool
Downstream elev. (ft)	5,140	5,140	4,920	5,120	5,120	4,920	4,760	5,000	4,760
Canopy density	65%	45%	70%	60%	60%	60%	70%	65%	80%
Ave. outflow temp. (°C)	9.3	10.8	9.5	9.7	9.7	10.2	9.8	9.6	9.1
Max. outflow temp. (°C)	10.7	12.4	10.8	11.2	11.2	11.7	11.3	11.1	10.4

Reach #	19	20	21	22	23	24	25	26	27
Stream	Upper Cool	Upper Cool	Upper Cool	Upper Cool	W. Cool	W. Cool	W. Cool	W. Cool	Lower Cool
Downstream elev. (ft)	4,500	4,800	4,500	3,940	4,600	4,240	4,240	3,940	3,600
Canopy density	45%	55%	80%	50%	50%	70%	70%	70%	70%
Ave. outflow temp. (°C)	12.1	10.8	9.7	13.0	11.6	11.0	11.0	11.6	12.3
Max. outflow temp. (°C)	14.2	12.5	11.1	15.3	13.5	12.7	12.7	13.5	14.4

Reach #	28	29	30	31	32	33	34	35	36
Stream	Lower Cool	Lower Cool	Lo Cld Spr	Lo Cld Spr	N. Ice	N. Ice	N. Ice	N. Ice	N. Ice

Cold Springs Creek - CWE Prediction

Reach #	1	2	3	4	5	6	7	8	9
Stream	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr	Up Cld Spr
Downstream elev. (ft)	3,400	3,360	3,200	3,040	4,300	4,300	4,000	3,600	3,200
Canopy density	40%	80%	70%	70%	40%	50%	40%	85%	85%
Ave. outflow temp. (°C)	14.9	12.2	13.2	13.6	12.9	12.2	13.6	11.3	12.2
Max. outflow temp. (°C)	17.6	14.2	15.5	15.9	15.2	14.3	16.0	13.1	14.2

Reach #	37	38	39	40	41	42	43
Stream	N. Ice	S. Ice	S. Ice	S. Ice	Lo Cld Spr	Lo Cld Spr	Lo Cld Spr
Downstream elev. (ft)	3,040	3,800	3,400	3,040	3,000	2,800	2,700
Canopy density	70%	70%	90%	80%	50%	70%	50%
Ave. outflow temp. (°C)	13.6	11.9	11.4	12.9	15.1	14.1	15.7
Max. outflow temp. (°C)	15.9	13.9	13.2	15.1	17.8	16.6	18.6

Table 6. Temperature Modeling Comparisons for 7/27/98 Calibration

Parameter/location	Measured (°C)	Heat Source (°C)		SSTEMP (°C)	
		simulated	deviation	simulated	deviation
Reach 27 average temperature	14.5	13.9	-0.6	14.5	0.0
Reach 27 maximum temperature	15.9	16.7	0.8	17.1	1.2
Reach 41 average temperature	15.6	14.3	-1.3	14.8	-0.8
Reach 41 maximum temperature	17.4	15.5	-1.9	18.0	0.6
RMS deviation (all)			**1.25**		**0.78**
RMS deviation in maximums			**1.46**		**0.95**

Table 7. Temperature Modeling Comparisons for 8/6/99 Prediction

Parameter/location	Measured (°C)	Heat Source (°C)		SSTEMP (°C)		Measured - ave. '98-'00 (°C)	CWE (°C)	
		predicted	error	predicted	error		predicted	error
Reach 27 average temperature	12.0	13.1	1.1	12.9	0.9	13.3	12.3	-1.0
Reach 27 maximum temperature	13.3	15.6	2.3	15.4	2.1	14.5	14.4	-0.1
Reach 41 average temperature	13.5	13.6	0.1	13.2	-0.3	14.6	15.1	0.5
Reach 41 maximum temperature	14.9	14.6	-0.3	16.1	1.2	16.2	17.8	1.7
RMS error (all)			**1.28**		**1.30**			**1.01**
RMS error in maximums			**1.64**		**1.71**			**1.17**

Appendix 14. Response to Comments

Appendix 14. Response to Comments

February 28, 2001

The draft *Upper North Fork Clearwater Subbasin Assessment and Total Maximum Daily Loads* was made available for public comment on November 20, 2000. Two individuals and four organizations provided written comment (Table 14-1). This appendix presents the public comments and provides DEQ's responses to them. We appreciate the comments received in that they add substantial information and documentation to the subbasin assessment and TMDLs.

Note: Public comments received and addressed in this appendix refer to a draft of the subbasin assessment and TMDL that was developed in November 2000 and submitted to USEPA in February 2001. The USEPA did not approve that document and returned it to DEQ for revision in December 2001. This October 2003 revision of the document has been substantially reorganized following DEQ's new subbasin assessment and TMDL format such that sections referred to in these public comments are not the same as those that appear in the current document. The final revision requested by USEPA, and a discussion of DEQ's response, is presented in Appendix 15.

Table 14-1. Summary of public comments.

Commenter	Type of Comment	Date of Comment
Mark Solomon P.O. Box 4087 Moscow, ID 83843	Email	Dec. 5, 2000
Dave Sandersfeld Email: fnature@hotmail.com Concerned Citizen	Email	Dec. 11, 2000
Doug Gochnour, Acting Forest Supervisor Clearwater National Forest 12730 Highway 12 Orofino, ID 83544	Letter	Dec 15, 2000
Samuel N. Penney, Chairman Nez Perce Tribal Executive Committee P.O. Box 305 Lapwai, ID 83540	Letter	Jan. 2, 2001

Commenter	Type of Comment	Date of Comment
Curry Jones Environmental Protection Specialist USEPA Region 10 1200 Sixth Avenue Seattle, WA 98101	Letter	Dec. 21, 2000
Robert McKnight, Area Supervisor Clearwater Supervisory Area Idaho Department of Lands 10230 Highway 12 Orofino, ID 83544	Letter	Jan. 8, 2001

Mr. Mark Solomon

Mr. Mark Solomon**,** who is a member of the Clearwater Basin Advisory Group as the environmental group representative, commented by email.

"Please accept this as a comment on DEQ's decision to not write sediment TMDLs for listed streams in the Upper North Fork Clearwater River, especially those listed for bull trout recovery under either the "Idaho Plan" or EPA's designation of bull trout streams for purposes of temperature compliance.

I would refer you to the section on bull trout in the recently submitted BA for the Potlatch mill discharge for a discussion with cites on the effects of fine sediment on bull trout. Pages 53-55. One sample: "This long time (3 weeks as fry) spent within the substrate makes bull trout extremely vulnerable to fine sediment accumulation and water quality degradation. (Fraley and Shepard, 1989)"

Other literature cited includes: Megahan et al, 1980; Lisle, 1982; Beschta and Platts, 1986; Everest et al, 1987; Clifton, 1989; USFWS, 1998.

As was demonstrated by the complete absence of any bull trout in fishing samples referenced in the UNFCR Subbasin Assessment, these streams have been hammered. Recovering bull trout will require active steps to reduce sediment loading as well as reducing in-stream temperatures. DEQ must write TMDLs for control of fine sediments in these streams."

DEQ Response: *Mr. Solomon's analyses and conclusion may be correct, but what he is requesting as a solution, in terms of sediment TMDLs for bull trout restoration, is outside the scope of the federal Clean Water Act, the federally promulgated water quality standards for bull trout, and Idaho's water quality standards. Basically, bull trout restoration is required under the federal Endangered Species Act, not the Clean Water Act. The federally promulgated standards for bull trout under the Clean Water Act address only temperature, for which we have developed TMDLs in this document. Idaho's water quality standards for sediment in these streams require that beneficial uses be supported. The designated beneficial use for these streams is "salmonid spawning," but is not specific to the species of salmonids that must be present. All of the water bodies assessed in this document, except Deception Gulch, support salmonid spawning at levels that meet or exceed the state's water quality standards as determined through implementation of the* Water Body Assessment Guidance*.*

The absence of bull trout in these streams does not imply a sediment problem. There are several other possible reasons for the absence of bull trout in these streams. Most of these streams have healthy populations of westslope cutthroat trout, which are also sediment sensitive. Some research indicates that cutthroat are more sensitive to sediment than bull trout. In the final analysis, however, to develop a TMDL for sediment, it is necessary to first show that there is a sediment problem, and then to show that the sediment problem exceeds the applicable water quality standards.

Further, DEQ concludes that the Clearwater National Forest is taking active steps to reduce both heat and sediment inputs to all streams in their jurisdiction. They are implementing INFISH, which stipulates that no timber harvest shall occur within 300 feet of a perennial stream. This management practice will reduce stream temperatures as natural canopies recover, and it will provide a buffer to any sediment that might be produced further upslope. The Clearwater National Forest also has an active program of obliterating the most unstable and sediment-producing roads, with the goal of obliterating one-third of the roads on the forest. We conclude that the in-stream sediment condition has been improving for at least the last decade, will continue to do so under their current management plans, and already meets Idaho's water quality standards.

Mr. Dave Sandersfeld

Mr. Dave Sandersfeld provided the following comment by email:

> Affiliation = Concerned citizen
>
> Comments = My background is geotechnical and environmental engineering and I am familiar with the water quality problems in the Clearwater Drainages - largely caused by exposing the very fragile, Idaho batholith soils. It took thousands of years for Nature to stabilize these soils and man can reverse the process in hours!
>
> I am very grateful to the Idaho DEQ for taking the initiative for eventually healing these scars along the Clearwater River. These scars have been ignored for decades!
>
> Your proposed TMDLs will not only help protect the Clearwater drainage; but our floundering native salmonoid runs.
>
> Well done
> Dave Sandersfeld 208-461-1142

Mr. Doug Gochnour, Acting Forest Supervisor, USFS Clearwater National Forest

Mr. Doug Gochnour, Acting Forest Supervisor for the USFS Clearwater National Forest commented on eight different points of the report. We present the USFS comments and the DEQ responses, point by point.

Section 4.3.2 Heat Sources:

In the fourth paragraph, the report noted that removal of the watershed canopy (not the riparian canopy), in some cases, could decrease late season stream flow and therefore increase water temperature. We agree that some of the literature makes this point, however, we have no evidence that this situation exists in the North Fork Clearwater River Subbasin. In fact, there have been some observations that clearcutting in the North Fork Clearwater River watersheds has extended late season stream flows in the headwater streams. The data that exists within the UNFCRS on increasing or decreasing streamflow due to canopy changes and the resultant heat generated is inconclusive. This point should be clarified.

DEQ Response: *We agree with the USFS comment and appreciate their further input that their observations tend to support the idea that timber removal does not decrease late season flows in the UNFCRS. We did not allocate any heat load reduction as a function of this process because we did not have any evidence that it occurs in the UNFCRS. We made the general statement in section 4.3.2 to alert readers that we had considered the situation as a possibility. We have added the following statement to section 4.3.2, "The CNF notes that their data for the UNFCRS on increasing or decreasing stream flow due to canopy changes is inconclusive."*

Sections 6.2 Cold Spring Creek, 6.3 Cool Creek, and 6.13 Lower Orogrande Creek:

Within the individual stream write-ups, conclusive remarks were made that "water quality would be greatly improved if the CNF were to address these problems" within each of the above referenced drainages. We would like to submit that the Forest has already identified the erosional and sedimentation problems and has either started or is proposing appropriate watershed restoration projects. Within the Cold Springs Creek and Cool Creek drainages, approximately 22 and 20 miles of roads are being proposed for decommissioning (road obliteration) and long-term intermittent use (LTIU), respectively, under the Middle Black EIS analysis; implementation would be scheduled between 2001 and 2010. Within the lower Orogrande Creek drainage the Forest has completed 51.1 miles of road obliteration and 0.9 miles of LTIU between 1995 and 1999 within the Pine Creek, Fuzzy Creek and Clark Mountain tributaries. Additional roads within the Clark Mountain area have been identified as possible decommissioning candidates; additional surveys and subsequent NEPA analysis are needed.

DEQ Response: *We stated a few times in the report that the CNF has plans to obliterate approximately 30% of the roads in the UNFCRS, and in no way intend to belittle this effort by the statement quoted. We appreciate receiving data for the numbers for the miles of roads obliterated in the three watersheds mentioned, and have added them to the report. We think the CNF efforts to decommission roads are exactly the kinds of measures that are needed to restore water quality. The statement quoted, however, appears in our discussions of many of the watersheds discussed in Section 6. The intent of the statement is to encourage the CNF to continue to look carefully at the road drainage and maintenance situation with roads that remain part of their system.*

Sections 6.2 Cold Springs Creek and 6.3 Cool Creek:

There are statements under both these sections that indicate there was no (or little) sediment delivery to Cold Springs and Cool Creeks during the 1995-96 landslide event. The report also noted that the surveys conducted by Clearwater BioStudies Inc. indicated definite effects of mass failure derived sediment in the stream channels. Information provided to your agency regarding the 1995-96 landslides in Cold Springs and Cook creeks was incorrect. There were, in fact, 11 landslides in the Cold Springs creek watershed (including Cool Creek) that delivered between 600 and 2, 800 cubic yards of sediment to the streams. In Cool Creek, there were three landslides that delivered between 300 and 1,200 yards of sediment to the streams. This information is consistent with the comments made in the Clearwater BioStudies Inc. report.

DEQ Response: *We appreciate the clarification and have made the changes in the text. We had noted the discrepancy between the CNF landslide data set and the Clearwater BioStudies Inc. report, and this new information clears up the problem.*

Section 6.5 Deception Gulch:

The forest has designated Deception Gulch and the adjacent drainages within the previously private-owned lands as the highest watershed restoration priority within the Upper North Fork Clearwater River Subbasin. Approximately 93 percent of the roads within the Deception Gulch drainage are scheduled for decommissioning or placement in long-term intermittent use (LTIU). Within the Deception Gulch drainage, approximately 38 and 11 miles of road have been approved for decommissioning (road obliteration) or LTUI, respectively, under the Deception Gulch Road Obliteration/OHV Train NEPA documents (Decision Notice signed July 19, 1999). In addition, 3.0 miles of road are being proposed for LTIU under the Middle Black EIS analysis. Project implementation would be scheduled for 2001-2010.

Watershed restoration was started in the Deception Gulch area in 1999 with 16 and 3.4 miles of road miles decommissioned (road obliteration) or placed in long-term intermittent use (LTIU), respectively, in the Comet Creek and face drainages along the mainstem North Fork Clearwater River. An additional 27 and 5 miles of road within the smaller face drainages along the mainstem North Fork Clearwater River have been approved for decommissioning (road obliteration) or LTIU, respectively, under the

Deception Gulch Road Obliteration/OHV Trail NEPA documents (Decision Notice signed July 19, 1999). Finally, approximately 45 and 29 miles of road within the smaller face drainages along the mainstem North Fork Clearwater River are proposed for decommissioning (road obliteration) or LTIU, respectively, are being proposed under the middle Black EIS analysis; implementation would be scheduled between 2001-2010.

DEQ Response: *This is certainly good news in terms of improving the sediment condition of Deception Gulch and meeting the sediment load reduction targets of the TMDL. We expect that documentation of these plans should be sufficient as an implementation plan for the Deception Gulch sediment TMDL.*

Section 7.1.5, Surrogate Water Temperature Targets:

The "Canopy Closure/Stream Temperature Evaluation" process that was used to determine surrogate water temperature targets is most likely valid for smaller headwater streams. Conclusions based on information presented in this section, such as the miles of stream segments with inadequate shade and the number of stream miles requiring 100 percent shade, need to be tempered with reality. Riparian areas along streams do not naturally exhibit 100 percent canopy cover for the entire length of the streams. Natural events (fires, landslides, wind events) may affect riparian vegetation along small stream segments or entire streams. In addition, larger streams (i.e. Middle Creek, lower Orogrande Creek) have larger stream widths that do not allow for a high canopy closure. The process does show utility in providing support that various streams may never reach water temperature standards naturally.

DEQ Response: *The point is well taken and clarification is important. We have added the following statement to section 7.1.5, "Riparian areas along streams do not naturally exhibit 100 percent canopy cover for the entire length of the streams. Natural events (fires, landslides, wind events) may affect riparian vegetation along small stream segments or entire streams. In addition, larger streams (i.e. Middle Creek, lower Orogrande Creek) have larger stream widths that do not allow for a high canopy closure. We have not attempted to sort out these site specific conditions in relation to the CWE predictions, but leave this for the land managers as they develop their implementation plans."*

Section 7.2.1. Sediment Loading Capacity:

In the fourth paragraph the statement "In general, the roads in Deception Gulch are mostly in very good shape or are closed and vegetated" is not correct. Road surveys indicated while most of the roads were closed and were somewhat vegetated, most were not in good shape. Based on the active erosional sites and high mass wasting potential found in these field surveys, the Deception Gulch and surrounding drainages were designated a high priority for watershed restoration.

DEQ Response: *The correction has been made.*

Section 7.2.2 Sediment Load:

In this section, three of the Forest Plan standards are discussed in relation to Deception gulch: geomorphic threshold (Basic), Low fish, and Minimum Viable. The Forest would never manage this watershed at the Low Fish or Minimum Viable standard as these standards have sediment levels that exceed the watershed geomorphic threshold. Therefore, some clarification is needed into how the forest interprets its standards. The current Forest Plan standard for Deception Gulch is "B" channel, Cutthroat Low Fish, which equates to 225 percent sediment over natural. In the case of Deception Gulch, the Low Fish standard (255%) exceeds the estimated geomorphic threshold of 163 percent sediment over natural. Because the geomorphic threshold equates to the Basic standard of, "maintain the stability, equilibrium, and function (physical and biologic)" of all streams, a higher fisheries standard is needed to meet or exceed the Basic standard. A Forest Plan amendment would be in order to change the standard from low fish (225%) to moderate fish (150%) to meet or exceed the Basic standard criteria. This amendment will take place in the Decision Notice for the Middle-Black Analysis. In the interim, we will manage the watershed below the 163% geomorphic threshold.

DEQ Response: *We appreciate the information that the Forest is proposing to manage Deception Gulch to meet their moderate fish standard. Similar to our response above, this plan on the part of the CNF should help insure that targets for the Deception Gulch will be met. We note that the Deception Gulch sediment TMDL continues to use 225 percent over background as the target to meet the state's water quality standards.*

For the purposes of clarification, we reiterate our rationale for choosing the 225 percent over background target. Once we decided that Deception Gulch is not fully supporting its beneficial uses, at least in part because of sediment, then we had to decide what would be an appropriate target load for sediment where beneficial uses would be supported. Our discussion in section 7.2.2 of the different CNF standards helped us identify the 225% over background as an appropriate target. We have added the following paragraph to section 7.2.2 to clarify this reasoning:

"We consider that for a population to be 'viable', it must have enough individuals and enough interconnected, suitable habitats to have a high probability of long-term persistence. Thus, if a population is indeed 'viable' as defined by the CNF, then the waters in which the population occurs would also meet the following definition of waters protected for 'salmonid spawning' in Idaho's water quality standards: 'waters that provide or could provide a habitat for active, self-propagating populations of salmonid fishes.' Therefore, the CNF goal of 'minimum viable,' if met, would support salmonid spawning. The CNF goal of 'low fishable,' which is defined as water providing a harvestable surplus in addition to maintaining viability, would exceed the minimum standard of salmonid spawning as defined by Idaho's water quality standards, subsection 100.01(b). Idaho's water quality standards are silent on harvest goals. Idaho considers harvestable surpluses to be a fisheries management issue, not an issue of meeting water quality standards."

We, therefore, applied the 225 percent over background as our target based on a conclusion that the CNF standard of "minimum viable" probably equates to Idaho's standard for salmonid spawning, but we allowed for a margin of safety by choosing the sediment loading for the next more stringent CNF standard, "low fishable." We assumed that the actual numbers for percent loading over background of the different CNF standards are more-or-less correct. And, as noted above in the added paragraph, we applied that target number by virtue of how it comports with Idaho's water quality standards, and not because it is a particular CNF standard or fisheries harvest goal.

In addition, as we note in the report, we conducted a logic test of the 225 percent over background target by comparing the results of implementing sediment reductions to meet this target to conditions of other watersheds in the subbasin where salmonid spawning is being supported. We concluded that the reductions in roads and mass failures that would be required to meet this target would result in lower road and mass failure densities in Deception Gulch than in watersheds with similar landtypes where salmonid spawning is being supported.

In another test of the numbers associated with this target, we compared the results predicted by WATBAL with those predicted by CWE, and found them to be reasonably close. We recognize that the CNF has confidence in WATBAL because it was developed and validated on the CNF. The primary author of this report has worked extensively with CWE. The fact that both models predict similar current loading from roads and mass failures, and require similar amounts of reduction to meet the target, indicates that the numbers are reasonable within our ability to understand the situation. The fact that the CNF is setting a target for this watershed that exceeds the TMDL target should assure USEPA and other concerned parties that in fact Idaho's water quality standards will be attained.

Sections 7.2.5 Surrogate Sediment Load Reduction Targets and 7.2.6. Sediment Reduction Margin of Safety:

In both these sections the recommendation is made, "that within the next few years the CNF obliterate all roads on hazardous landtypes..." It is not possible for the Clearwater National Forest to accomplish this recommendation. We cannot obliterate all roads on hazardous landtypes, including the 225 (mentioned), 729, 730, 734, and 735 roads. These roads provide access to the watershed for management and fire control. We can most likely agree to obliterate half the 42 miles of roads, concentrating on the roads on hazardous landtypes. We can also agree to reduce the mass wasting hazard on roads that will not be obliterated. We may need up to five years to accomplish this task. We would like to see a statement to the effect that accomplishment of the recommendation is dependent upon funding. Although we intend to make road obliteration in this watershed a high priority, if the Forest is not funded by Congress to do road obliteration, we cannot accomplish the work.

DEQ Response: *We have made the recommended changes to read as suggested. In fact, we were over-prescriptive in designating which roads and mass failures should be* *controlled. This is a decision to be made by the land managers in the process of developing an implementation plan. The bottom line of the implementation plan for non-point source pollution is that the land manager(s) (the CNF in this case) demonstrate that they will meet the sediment reduction target – a 45% sediment reduction in the case of Deception Gulch. The choice of where and how to do this is largely a decision of the land manager(s).*

The CNF Forest Supervisor goes on to make the following point:

Perhaps more importantly, we strongly disagree with the statement (Section 6.0: Water Quality Data summary and Conclusions, first paragraph*),* "Due to time constraints, we are not evaluating any water bodies not included on the 303(d) list even though we suspect a large number of them in the UNFCRS do not meet the temperature standards. We recommend that these water bodies be considered for formal 303(d) listing and evaluated in the next round of TMDL development starting in 2006." There are over 200 named streams in the Upper North Fork Clearwater River Subbasin that most likely cannot meet the current EPA bull trout water temperature standard or State temperature standard for salmonid spawning. In 1999, the Forest monitored water temperatures at 87 sites on 75 streams within the North Fork Clearwater River drainage. The bull trout water temperature standard (expressed as a consecutive seven-day average of daily maximum temperatures) of not to exceed 10^{o}C during the June through September period was met on only one stream (Birch Creek). These 75 streams are located both in non-roaded and non-harvested watersheds (i.e. Fourth of July, Black, Fern, Toboggan, Train creeks) as well as roaded and harvested watersheds (i.e. Birch Creek). Listing several hundred more streams where we can do nothing to decrease stream water temperature is not the answer. The standards must be modified to meet natural stream temperature ranges that exist in these watersheds. Until that step is accomplished, streams will be listed as WQLS and TMDL's will be developed where there is no solution or closure to the problem.

We are also concerned that many streams you are recommending for TMDL development for stream temperature in the UNFCRS are already meeting beneficial uses (China, Cold Springs, Cool, Cougar, Gravey, Grizzly, Laundry, Marten, Middle, Lower Orogrande, Sugar, Swamp, Sylvan, Tamarack, and Sneak creeks). These same streams had high MBI's and two or more age classes of fish, indicating that beneficial uses are met. Because of this, these streams were dropped from the 303(d) list for sediment. The recommendation to add them back to the list for temperature appears inconsistent. The fact that beneficial uses are met, yet water temperatures exceed the standards, further indicates that the standards need modification. We recommend, before the 2006 TMDL development, that the DEQ correct the water temperature standards to reflect natural conditions and ranges of variability within these watersheds.

Again, we appreciate the opportunity to comment on this document. If you have any questions or comments regarding this letter or conditions in the North Fork of the Clearwater River, please contact Pat Murphy or Dick Jones at 208-476-4541.

DEQ Response: *The point about the need to "correct the water temperature standards to reflect natural conditions and ranges of variability within these watersheds" is well taken, and we at DEQ are aware of the problem. We received virtually the same comment from the Idaho Department of Lands (included herein). Since comments for the UNFCRS are received at the DEQ Lewiston Regional Office, we have forwarded your comments via memorandum to the DEQ State Water Quality Programs Administrator. Our intent with this memo is to assure the commenters that we have raised this question to the appropriate level within DEQ.*

With respect to the CNF point in the second paragraph above that there is an inconsistency between what qualifies for full support of beneficial uses for sediment as opposed to temperature as pollutants, a similar point was made by IDL. The difference lies with how "narrative" and "numeric" water quality standards are interpreted and applied. Numeric standards leave little or no room for interpretation, while narrative standards are applied based on assessment of local conditions and support of beneficial uses. Correction of the state's water temperature standards will provide more consistency between the two types of standards, but discrepancies will continue to occur because of the different nature of the two types of standards. In the UNFCRS, we thought it was important to identify the pollutant most likely to be causing problems; therefore, we developed TMDLs for temperature rather than sediment.

In fact, for water bodies that are to be protected for bull trout spawning and rearing, we think temperature is a problem, and stream temperatures need to be reduced. It seems reasonably clear to us after having looked at the UNFCRS that bull trout restoration will require stringent management for water temperature control.

Mr. Samuel N. Penney, Nez Perce Tribal Chairman

Mr. Samuel N. Penney, Nez Perce Tribal Chairman, provided a number of comments to the document, as follows:

The Nez Perce Tribe appreciates the opportunity to comment on the Total Maximum Daily Load (TMDL) for the Upper north Fork of the Clearwater River. Portions of the Upper North Fork of the Clearwater River are within the Tribe's ceded territory. The Tribe continues to exercise its treaty-reserved hunting, gathering, and fishing rights in these areas.

The Tribe commends the Idaho Department of Environmental Quality (DEQ) on the hard work and effort put forth completing this document. We believe that this draft forms a good framework up which to develop a final TMDL.

General Comments

Water Body Assessment Guidance

Of major concern to the Tribe is the continued reliance this TMDL places on the 1996 Waterbody Assessment guidance (WBAG). The TMDL utilizes this WBAG to make significant determinations, including decision to not proceed with completing a TMDL.

As you know, the Environmental Protection Agency has expressed significant concern with the WBAG. In fact, DEQ is currently completing the development of a new assessment process. Allowing the continued use of the 1996 WBAG prevents the meaningful achievement of the Clean Water Act's goals of restoring and maintaining the chemical, physical, and biological integrity of the nations' waters.

Given the development of a new WBAG, the Tribe would recommend that DEQ postpone finalization of this document pending the approval of the new assessment guidance. While the Tribe recognizes that DEQ is under a court approved schedule for completing TMDLs, there is a process for seeking an extension of the deadline. Further, given the ongoing lawsuit over the TMDL schedule, there may be an opportunity to seek an extension through settlement discussions with EPA and the plaintiffs. Compromising the scientific and legal defensibility of the TMDL in order to meet the TMDL schedule is not consistent with the goals of the Clean Water Act and with DEQ's legal obligations to produce a TMDL that will lead to achievement of water quality standards.

DEQ Response: *We appreciate the Tribe's concerns about the 1996 WBAG process and understand that both the Tribe and USEPA are hopeful that the new WBAG process will change the support status calls for some of the water bodies in the UNFCRS. We have in fact made significant determinations using the 1996 WBAG process, but in the mode known as the "WBAG plus" where we consider other data. We think determinations made in this mode are as stringent, or perhaps more so, as will be possible under the new WBAG. In the final analysis, however, given the need to continue developing TMDLs to* *meet the court agreed upon schedule, we use the tools we have available, and the 1996 WBAG plus is the process we have in place.*

We do not believe that there is any good justification for postponing the finalization of this document, especially in light of what we expect to be full and rapid implementation of water quality improvement plans by the CNF. We think we have made a fair assessment of the subbasin, and that for the most part, the new WBAG will also indicate that beneficial uses are being fully supported. The CNF's comments above with respect to Deception Gulch, and their plans for road closures and full implementation of INFISH standards indicate that they are moving rapidly to bring all streams under their jurisdiction into compliance with state and federal water quality standards. In fact, given ongoing watershed restoration activities of the CNF, there are good reasons to conclude that the TMDLs in this document are unnecessary.

WATBAL

This TMDL extensively utilizes information obtained from the Forest Service's WATBAL erosion model. The WATBAL erosion model has been shown to chronically underestimate potential sedimentation mainly due to the lack of an effective method to model and predict mass failure. R. Hickley, *Evaluating the WATBAL Sediment Loading Model*, at 233-242. WATBAL assumes incorrectly that sediment sources generated from roads and logging heal after four and six years, respectively. This assumption is clearly far from reality, especially in a subbasin, such as the North Fork, that contains highly erosive soils.

Sediment loading modeling by WATBAL "have been invariably underestimated, potentially settling the state for the long-term damage to the stream." *Id*. Use of WATBAL provides estimated sediment delivery rates that are low enough so that additional sediment can be generated by human activities without affecting fish habitat or water quality. Use of the WATBAL model in the TMDL should be carefully reconsidered understanding the limitations in the model.

DEQ Response: *In fact, this TMDL uses very little WATBAL derived information. We present some selected WATBAL derived data as general background information, but have not made any decisions based on WATBAL. Generally, DEQ has been requested to present all available data for subbasin assessments. WATBAL derived data are the most complete data sets for this subbasin, and we concluded that it is important to present some of the results. However, according to DEQ standards, WATBAL data does not qualify as adequate for making beneficial use support calls. Support status calls for each watershed were made using BURP data and data from the CNF bio-physical studies (which are not WATBAL based).*

In the case of the sediment TMDL for Deception Gulch, we note in the report that WATBAL sediment delivery predictions were in fact about 50 percent less than CWE predictions. We used the CWE predictions to produce the sediment budget for Deception Gulch. In the case of the sediment target for Deception Gulch, if WATBAL underpredicts *sediment delivery, then it also underpredicts the targets derived through WATBAL analyses, i.e., the amount of allowable sediment for a given fisheries goal. Since we use CWE predictions and individual mass failure assessments to produce the sediment budget, use of an underpredicted sediment target would result in an extra margin of safety.*

Specific Comments

3.3 Cultural Characteristics

There is no mention of cultural use by the Nez Perce Tribe. The document needs to address these issues.

DEQ Response: *We apologize for the oversight. We have added the following paragraph to this section:*

"The Nez Perce people have been residents in the study area for over 8,000 years. The UNFCRS is within the Nez Perce Tribe's ceded territories. The Treaty of 1855 reserved fishing, gathering, and hunting rights in these areas. The Nez Perce Tribe's treaty-reserved interest in maintaining and utilizing natural resources is important to their sense of community. The fishery, and the waters supporting it, are revered by the Nez Perce for the life and sustenance these resources have given, and continue to provide, to Tribal members."

6.0 Water Quality Data Summary and Conclusions

The proposal to delist all streams except Deception Gulch for sediment is of concern. As stated in the document, there are several attributes of the subbasin that cause sediment to be of concern for water quality. At lower elevations over-steepened slopes are susceptible to erosion and mass wasting. In fact, many landslides have occurred. Soils in the subbasin are highly erodible and, when exposed during road construction and other disturbances, are difficult to stabilize. Rain-on-snow events can lead to huge amounts of runoff, and produce large amounts of sediment. Timber harvest has denuded many slopes. As reported in the document, during the 1995-96 season there were 370 landslides reported in the subbasin due to storm events. Anthropogenic disturbance accounts for almost 60% of those mass failure events. Given the level of sediment sources to streams in the subbasin, we question the conclusion that sediment is not a water quality pollutant of concern.

DEQ Response*: We agree that sediment is a water quality pollutant of concern in the UNFCRS. We present considerable data and discussion of sediment. However, in the end, we determined that sediment is not degrading water quality below the state standards, except in Deception Gulch. The water quality assessment process, as prescribed by the Clean Water Act, must use specific standards set by the state and approved by USEPA. Concern for sediment as a pollutant can only be translated into a TMDL if it exceeds the specific state's standards. For sediment the criteria are* *narrative, thus we rely upon bioassessment techniques, as formalized in WBAG, to gage sediment affects on beneficial uses.*

While there were a large number of mass failures in the 1995-96 event, a better indicator of their potential effect is the delivery of sediment to a stream. We specifically looked at sediment delivery data and compared them to in-stream effects in terms of beneficial uses. The presence of several age classes of salmonids in these streams indicates that the beneficial uses are still being supported and sediment TMDLs are not necessary.

We continue this response by pointing out that the objective of the state's water quality standards is not to preserve water in pristine condition. Our goal in assessing the water quality in a subbasin is not to determine whether any degradation has taken place or not, but rather to determine whether degradation that has taken place is of a nature and extent that it exceeds the state's water quality standards. What we have observed in the UNFCRS subbasin is that what most people would consider as huge amounts of anthropogenic sediment can be added to these water bodies and they are resilient enough to continue to support their beneficial uses, in terms of salmonid spawning as defined by the state's water quality standards. Our task has been to try to identify and quantify the level of sediment input beyond which beneficial uses will not be supported. We think we have erred on the side of protecting beneficial uses in our analyses, as defined in Idaho's water quality standards.

In particular, we disagree with the use of the presence of fish as evidence that sediment is not a water quality pollutant of concern. Under the current WBAG guidelines, fish density per age class is not considered in determination of salmonid spawning beneficial use, a stream can have serious degradation due to sediment and still support fish. Even in streams where greater numbers of fish are observed, sediment can still be having a large impact on water quality. Again, we suggest that the new WBAG guidelines be used. Also, measures such as cobble embeddedness and percent fines are much more accurate determinants of sediment impacts to water quality.

DEQ Response: *While we agree that sediment is a water quality pollutant of concern in the UNFCRS, our use of presence of age classes of fish is the state's prescribed metric at this time to determine beneficial use status. We understand that the Tribe thinks that this metric is inadequate and is hopeful that the metric will be changed to include fish density and population trend measurements. Given the relatively strong fish populations in the UNFCRS, we doubt that metrics being included in the new WBAG would change many, if any, of the support status calls.*

We disagree that cobble embeddedness and percent fines would be more accurate measures of the effects of sediment as a pollutant. While they can be related more directly to use impairment at a given location, they are highly variable conditions naturally and it would be very difficult to sort out natural conditions and human-caused effects in relation to the beneficial uses of a water body. In other situations, other habitat measures such as depth and type of pools could be the limiting factor for aquatic use.

The state has chosen aquatic life indicators of water quality because we think they are most applicable across the broad range of conditions found in our streams and rivers.

We support the conclusions on water quality that there are undoubtedly a large number of streams not currently on the § 303(d) list that do not meet Idaho state water quality standards. We hope that the recommendation that they be considered for formal § 303(d) listing and evaluation during the TMDL development starting in 2006 will be followed through.

DEQ Response: *We have already submitted these recommendations in a memorandum to the water quality monitoring division of DEQ. This is the first step in the formal process in evaluating these streams for water quality condition and possible 303(d) listing.*

Additionally, we suggest that entries in Table 6.1 be alphabetized for easier reference.

DEQ Response: *Good suggestion, the table is changed.*

Cougar Creek

The document states that sediment is "building up in the system," that there is high cobble embeddedness, and that there will not be a TMDL. Further, the TMDL states that salmonids do not occur in the upper reaches of the watershed speculating that this is "most likely the result of natural barriers." It is unclear if there is information to support this contention. Is it possible that habitat in the upper reaches is impaired by the sediment in the system?

Grizzly Creek

The document indicates that sediment may be building up in the Grizzly Creek watershed "either through input or inability to move it though the system very well." Further, the Clearwater Biostudies report indicates logging activities occurring to the stream side, in violation of Idaho law. Given the impact of these activities and the build up of sediment, a TMDL is warranted for this watershed to reduce further loading.

DEQ Response: *Cougar and Grizzly Creeks are side by side and have very similar conditions. Both are affected by logging debris and sediment. Both are in unstable geologic landscapes. Both are supporting populations of salmonids in their lower reaches, but do not have any salmonids in their upper reaches. Both were glaciated in their upper reaches approximately 12,000 years ago, such that fish populations were likely extirpated at that time. Migration barriers in their mid reaches have kept salmonids from repopulating the upper reaches. The Clearwater Biostudies report identifies 2-3 meter high water falls in their mid reaches that act as migration barriers. So, while the point is well taken that sediment from logging probably is impairing these systems, the existing data and metrics result in a conclusion that salmonid spawning,* *where fish have access, is being fully supported and the state's water quality standards are being met.*

Hem Creek

The document indicates that temperature exceedences in Hem Creek are a natural condition. What action will DEQ take to delist this stream?

DEQ Response: *Hem Creek is currently 303(d) listed for sediment, not temperature. We are proposing that Hem Creek be delisted for sediment, based on our assessment that it is fully supporting its beneficial uses. Simply, during the next round of 303(d) list development by the state, Hem Creek will not be listed as impaired by sediment. Since it is not currently listed for temperature, we will not list it for temperature either. While Hem Creek does exceed the state's water temperature standard, the watershed is in near pristine condition and we concluded that the stream temperature is natural.*

Upper Orogrande Creek

Despite the conclusions of the WBAG that this watershed is not meeting its beneficial uses, the document concludes that a TMDL for sediment is not required for this watershed. It is unclear what scientific and legal support there is for this decision. IDAPA § 58.01.02.053 requires that the WBAG be utilized to make determinations regarding beneficial use support. As stated above, DEQ may wish to postpone the finalization of this TMDL pending the approval of the new WBAG, which may provide an improved method for assessing sediment impacts on beneficial uses.

DEQ Response: *Upper Orogrande Creek is 303(d) listed for sediment. However, when we examined the data in terms of sediment sources and physical presence of sediment in the stream, we did not find any convincing evidence that sediment is a problem. Very few major sediment sources occur across the landscape, and the channel is mostly cobble-sized material with very little fine sediment. When one considers that upper Orogrande is in a highly weathered granitic landscape, low cobble embeddedness is strong evidence that sediment is not a problem.*

When we compared this to the temperature data, where the evidence is convincing that temperature is a problem, we concluded that the lack of beneficial use support is the result of temperature impairment, rather than sediment. We used the fairly extensive existing field data (CWE and temperature monitoring) to clarify the true pollutant of this water body. We believe this meets the legal intent of TMDLs within the CWA, and is scientifically defensible.

Osier Creek

The document notes that Osier Creek is listed on the § 303(d) list for sediment, temperature, flow, and habitat alteration. However, flow and habitat alteration are not addressed in the assessment and there was no TMDL completed for these pollutants.

DEQ Response: *To present, USEPA has accepted DEQ's position that flow and habitat alteration are not pollutants and, as such, do not require a TMDL. On Feb. 12, 1998, USEPA, in accepting the Paradise Creek TMDL, wrote, " First, EPA has not reached a resolution regarding habitat modification and flow alteration as pollutants under §303(d) of the Clean Water Act." USEPA has formalized this policy in their recently approved rule-making where flow and habitat alteration are classified as "pollution," as opposed to "pollutants," and as such, will not be subject to TMDLs because there is no pollutant to be assessed for loading and allocation. The likely pollutants that would be associated with flow and habitat alteration in Osier Creek are temperature and sediment. We assessed Osier Creek for both of these, and concluded that heat loading needed to be decreased through increased shading. Increased shading will improve the flow and habitat alteration situation. The CNF's implementation of INFISH with 300-foot no-cut buffers will restore stream flow and habitat to near natural conditions.*

Tamarack Creek

The document indicates that sediment is a problem for Tamarack Creek. WATBAL modeling, which tends to underestimate delivery, shows a high level of sediment delivery into Tamarack Creek. The CNF bio-physical survey indicates that sediment is a limiting factor in salmonid production (a beneficial use of Tamarack Creek). Given this information, a TMDL should be completed for this watershed.

DEQ Response: *While observed sediment levels are higher than we'd like, we find they are not so high as to be precluding full support of salmonid spawning. We state in the report that we too think that sediment is a problem in Tamarack Creek. However, based on the metrics used by the state process, water quality in fact meets the state's standards and no TMDL is required. Road density in the watershed is low, and virtually none of the roads are within 100 feet of a stream. The high levels of sediment seen by the CNF crew were noted the year after the 1995-96 rain-on-snow event, at which time they also observed cutthroat trout. The presence of a strong population of cutthroat trout shows that the water body is supporting its beneficial uses.*

Tumble Creek

It is unclear what data is utilized to support the contention that only brook trout utilize this watershed. Did DEQ conduct follow up surveys along additional stretches of the stream to confirm this contention? What sort of IF&G coordination occurred? Absent compelling evidence to the contrary, DEQ should assume that other trout species (i.e., rainbows) utilize Tumble Creek and therefore conduct a temperature TMDL for this watershed.

DEQ Response: *Data about brook trout presence in this stream come from both BURP data and the Clearwater Biostudies Report of a stream survey conducted in 1997. Neither the Clearwater Biostudies team nor the BURP crew identified other species of salmonids in Tumble Creek. The Idaho Department of Fish and Game does not have any* *current data on Tumble Creek, nor do they have any historical data for the presence of any other species. The WBAG process requires the use of relatively current data, all of which indicate that brook trout is the only species present in this water body.*

As stated above, it is likely that the conclusion that WATBAL is underestimating sediment delivery to Tumble Creek is correct.

It is unclear from the document what supports the conclusion that the lack of fish in the upper reaches is a result of natural migration barriers. Given the high cobble embeddedness (70%), it may be possible that the beneficial uses of the upper watershed are impaired by sediment. Given this uncertainty, a TMDL should be completed.

DEQ Response: *The Clearwater Biostudies report clearly identifies significant migration barriers in the middle reaches of Tumble Creek. While 70 percent cobble embeddedness is relatively high, this is highly weathered granitic terrain where cobble embeddedness is naturally high. We conclude that the lack of salmonids in the upper reaches is the result of the migration barriers, which were clearly identified in the Clearwater Biostudies report. We assume that if the water quality in the lower reaches meets water quality standards, then the water in the upper reaches must also meet water quality standards, absent any direct evidence to the contrary.*

Sneak Creek

The high road density and amount of canopy removal in the watershed are sources of concern for sediment impacts. WATBAL modeling predicts "a 90% over background sediment delivery from roads in the watershed." As stated above, WATBAL underestimates sediment delivery, not overestimates sediment delivery as stated in the document. There is nothing to support the notion that WATBAL is overestimating as opposed to underestimating sediment delivery.

Further, the CNF Biophysical survey indicates that high levels of cobble embeddedness are a limiting factor for salmonid production. This is confirmed by DEQ's own cobble embeddedness value of 34%.

DEQ Response: *Sneak Creek, along with Grizzly and Cougar Creeks discussed above, was one of the watersheds most recently entered after the CNF learned how to build better roads so they are more stable and produce less sediment. A CWE analysis of the roads conducted last summer by the TMDL team indicates that the roads in Sneak Creek are producing very little sediment. We, therefore, take our on-the-ground CWE results as strong evidence that sediment from roads is not a problem. Only one mass failure was recorded from the 1995-96 event. We simply do not find evidence for sediment production in this watershed.*

The level of cobble embeddedness compares as well to the situation in Grizzly and Cougar Creeks with similar geologies and landtypes. It may be natural or in part the result of sloppy logging several years ago, but we did not find any anthropogenic source *from which we can conclude that sediment delivery in an ongoing problem. If we could have identified a major, ongoing anthropogenic sediment source, we would have looked more closely at the need for a sediment TMDL.*

The data seems to indicate that a TMDL should be conducted for channel stability or sediment to address the problems in this watershed.

DEQ Response: *Certainly, no evidence exists that channel stability is a cause for a TMDL – the Clearwater Biostudies team surveyed the whole stream and did not identify any instance of channel instability and gave the stream perfect ratings. A sediment TMDL is not required because the water body is supporting its beneficial uses as evidenced by the presence of moderate densities of rainbow and cutthroat trout.*

The Tribe appreciates the opportunity to comment on this TMDL. If you have any questions regarding these comments, please do not hesitate to contact Barbara Inyan in the Water Resources Division. Thank you.

Mr. Robert McKnight, Area Supervisor, Idaho Department of Lands, Clearwater Supervisory Area

Mr. Robert McKnight, Area Supervisor of the Idaho Department of Lands, Clearwater Supervisory Area provided several comments, as follows:

Comments on the Upper North Fork Clearwater River TMDL

Consistency

After reading several subbasin assessments, it was very apparent that there is a terrible lack of consistency between them. For example, all subbasin assessments do not evaluate the support of beneficial uses the same way. Some evaluate data (BURP data and other pertinent information) as directed in the Water Body Assessment guide to determine support status. Others use the Water Body Assessment guide, but may alter their final decision based on other observations or data not used in the Guide. Finally, some subbasin assessments seem to ignore the Water Body Assessment Guide altogether and make support determinations using their own form of analysis which often is unsubstantiated.

DEQ Response: *The WBAG definitely allows and even encourages consideration of "outside data." The extent to which this is done varies with varying levels of available data and varying levels of skill and time for DEQ staff to gather and process that data. The bottom line, however, is that most of the inconsistencies are the result of growing pains at DEQ as we've geared up to do many TMDLs at the same time that our 1996 WBAG process has been called into question. We agreed to not use the 1996 WBAG for future assessments, but are constrained to keep producing TMDLs to meet the agreed upon court schedule. This leaves the regional TMDL writers to individually address the shortcomings of the 1996 WBAG in ways with which they are most comfortable, and largely in the absence of much guidance from Boise because the Boise program people are in the throes of developing the new WBAG.*

We attempted to address this by defining "WBAG plus" as a bridge between the old and the new. The "plus" was to represent a stronger push to use data beyond BURP and to supplement WBAG with data and procedures published by others. We even allowed that overwhelming evidence might be used to overturn a BURP-based assessment. Inevitably, this resulted in inconsistencies among the TMDL authors.

We hope the situation will be improved with the new WBAG, which is currently out for public comment. While no guidance can address all situations, we expect the new WBAG will help alleviate the high degree of inconsistency noted.

We found the same inconsistency on how different subbasin assessments evaluate water temperature. Some subbasin assessments evaluate stream temperature and require temperature TMDL's when State or Federal standards are exceeded. Other subbasin assessments review stream temperature, but even when temperature exceedences occur, they suggest putting off a TMDL until DEQ further evaluates the temperature standards. Finally, other subbasin assessments do not even mention temperature or suggest temperature TMDL's should be developed, even when one could clearly argue that there are temperature problems.

DEQ Response: *If a water body is not currently 303(d) listed for temperature, there is no obligation to consider developing a TMDL for temperature at this time. It may well be that temperature problems exist for currently unlisted water bodies, and it is no secret that many, if not most, water bodies in Idaho will fail to meet current criteria. We want to do temperature TMDLs where water temperature truly is a problem and is correctable. We do not have the luxury of assessing all water bodies in a subbasin, though some are pushing us to do exactly that. Thus, it has been left largely to the discretion of the regional TMDL writers to address temperature problems as they have time and see fit.*

The decision to proceed with some temperature TMDLs for the UNFCRS was largely based on a desire to establish a methodology for doing temperature TMDLs and to begin sorting out how to determine whether or not temperature exceedances are significant and correctable. In order to keep the exercise within the bounds of our time and resources, we focussed on currently listed water bodies in the UNFCRS, recognizing that probably most of the water bodies in the subbasin exceed the temperature standards. Please review the CNF comments above as they summarize the extent of temperature exceedances in this subbasin.

Finally, There appears to be an inconsistency between the level of disturbances that are allowed before sediment and temperature TMDL's are developed. The stream temperature standards are set near the optimum for the various fishes they apply to. Even though it is recognized that fish will thrive in warmer temperatures, the standards are set at near what is believed to be the best for fish. It doesn't even seem to matter that these standards are unachievable in many natural/undisturbed conditions.

DEQ Response: *It does matter to DEQ whether criteria are achievable, but the burden of proof is ours and there are some real skeptics. Historically, water quality criteria have not been set at the optimum, and we do not think this is the intent of the CWA. For example, with toxics, the optimum standard would be zero (for copper or PCBs, as examples), but we do allow some level of these pollutants up to what we think will support beneficial uses such as fishing. In the case of temperature standards, we have gotten ourselves into a bit of a box due to lack of understanding the natural variability of water temperature when the standards were established. Now we find it very difficult to convince certain critical players that Idaho's water quality standards for temperature are inconsistent with natural variability and the intent of the CWA.*

Without going into detail, suffice it to say that Idaho's water temperature standards for salmonids were set two decades ago based on laboratory studies that were not designed to address general in-stream temperature conditions. The results were incorporated into Idaho's standards when little was known or understood about natural temperature regimes in Idaho, and when few were concerned about stream water temperatures in

Idaho. We have since learned differently, and need to come up with a new set of water quality standards for salmonid spawning that make sense in our current knowledge base.

On the other hand, when evaluating what is acceptable as far as sediment delivery is concerned, it appears that all that really matters is that a fishery exists in the stream (2 or more age classes). It doesn't matter if the fishery is suppressed or going down hill, just as long as a fishery exists. The strategies used to evaluate these two pollutants make it difficult to understand what the goals of developing TMDLs are. Do we want to maintain and protect optimum stream conditions or should it be acceptable to maintain something considerably less just as long as the beneficial use still occurs?

DEQ Response: *(Part of our response to this question is the difference between "numeric" and "narrative" criteria, which is discussed above in our response to the CNF about inconsistencies between the two types of standards.)*

However, beyond that, DEQ is under strong pressure to raise the bar, so to speak, in terms of what qualifies as the lower limit for occurrence of fish and/or other aquatic life for a stream to be in full support of its beneficial uses. The criteria included in the new WBAG currently out for public comment is DEQ's attempt to meet this demand. Pertinent to this comment, however, is the point that the state water quality standards are not designed to maintain optimum water quality conditions, but conditions adequate to support the designated beneficial uses as defined in the WBAG. In the case of the narrative sediment standard for salmonid spawning, we agree that the current WBAG is a bit weak, and we've tried to raise that standard with the new WBAG. In the case of the numeric water temperature standards for salmonid spawning, we argue that the current standards are too restrictive and need to be changed to be consistent with the rest of our standards and/or the real world. If and when the temperature standards are revised, we will revisit the temperature TMDLs presented in this document.

The commenter is correct in observing that so long as a fishery is sustaining itself, albeit marginally, full support is there and narrative criteria are evidently met. The steady decline of fish populations is a concern and may indicate a decline in water quality (threatened but not yet impaired), or it may indicate other fisheries management problems.

These inconsistencies are very frustrating for land managers or anyone else concerned with the TMDL process and could result in lawsuits and even the refusal of individuals to implement TMDL's. All subbasin assessments should have similar outlines, evaluate beneficial uses with the same methodology, and use a similar procedure for developing TMDL's. This type of consistency will result in a better understanding for landowners, managers or operators on what it takes to protect beneficial uses and an overall better acceptance of this process.

Temperature Issues

We strongly approve of using the CWE temperature model to evaluate whether stream temperature standards are met. This model is simple enough for landowners and managers to use, and when implemented on the ground it has proven quite accurate. This is not too surprising as this model was developed from actual stream temperature data collected in Idaho. More complex models that use numerous variables such as humidity, air temperature and wind speed are difficult to understand and more difficult to implement, and often do not gain you more accuracy. As stated in this assessment, shade and elevation are clearly the driving force as far as stream temperature goes and in statistical tests these variables explained over 60-70% of the variation that occurs in stream temperature. In addition, variables such as wind speed, air temperature and humidity are all highly correlated with canopy cover and/or elevation and as a result these variables are essentially covered in the CWE model.

Where the CWE process clearly shows that water temperature is a problem because a lack of canopy cover occurs over the stream, the Idaho Department of Lands plans to manage these stream zones using the CWE Target Stream Canopy Closure tables. In many cases the trees exist but are not yet large enough to provide acceptable canopy coverage. There is a limited number of species that naturally occur in the riparian areas and most are slower growing. Much of the large white pine has died due to white pine blister rust. We would consider a stream as recovered once acceptable canopy cover levels are restored or once the stream reaches a natural level of canopy. This would be similar to the logic that was used to preclude Hem Creek from a temperature TMDL, which we approve of. It makes no sense to have a temperature TMDL on a stream that has natural levels of canopy occurring over it. It should also be noted that canopy coverages shown in the report do not address other factors such as topography, geography, channel type, and natural openings. All of these can provide or influence shading on a stream.

DEQ Response: *Factors such as topography, geography, channel type, and natural openings are expected to be addressed by the land manager in the process of developing the implementation plan, consistent with the FPA CWE process. We have revised the discussion for the development of temperature TMDLs in this document (Section 7) to more specifically address these other effects on temperature. We strengthened the discussion of the importance of shade to maintaining stream temperature as the basis of using percent stream shading as the surrogate measure of heat loading.*

However, land managers should clearly recognize that the pollutant is heat and that, in fact, the requirements of the TMDL will not be fulfilled until stream temperatures have been reduced enough to meet the state's standards. We believe that canopy restored to its fullest and most effective shading capacity of the so-called "natural conditions" for a given water body will reduce stream temperatures to near natural conditions, and should be sufficient for removing a water body from the 303(d) list. However, many water bodies have been manipulated to such a degree that it is relatively inconceivable that the so-called "natural" stream protection conditions could be fully restored. It is expected *that the land managers will address these conditions in their implementation plans for temperature reduction, recognizing at all times that the final measure for effectiveness of the implementation plan is in fact reduction of stream temperatures to meet the state's water quality standards.*

The major problem we have with the temperature TMDL's being developed in this subbasin assessment is the temperature standards (Federal and State) are unrealistic. We realize this is not necessarily something that can be addressed in this subbasin assessment, but these comments need to be brought out so something can be done about it. For example, the State temperature standard for cutthroat trout is, between April 1st and August 1st the maximum water temperatures must not exceed 13°C with the maximum daily average no greater than 9°C. For most people, the implications of these temperatures are not clear because most don't realize what type of water temperatures we should expect by August 1st and because most don't realize what a 9°C daily average really means. To help clarify how restrictive this standard is, it's important to understand the following two points. First, the warmest stream temperature of the year typically occurs within one week of August 1st. Second, a 9°C daily average applied during the warmest part of the year is about the same as a 9.7°C MWMT (this was determined using regression equations developed by Sugden et al. 1998). Remember, the Federal Bull Trout standard so many people have problems with is, the MWMT shall not exceed 10°C, so believe it or not, the State standard for cutthroat trout is actually more restrictive than the Federal Bull Trout Standard.

DEQ Response: *We, for the most part, agree with this statement that both the federal and Idaho's temperature standards for bull trout and salmonid spawning are unrealistic. That was not the understanding, or even a consideration, when the current criteria were developed over 20 years ago. We have transmitted these comments to the appropriate authorities at DEQ. Efforts are under way within DEQ and among USEPA and the states of Washington, Idaho, and Oregon to come up with more realistic standards. The temperature TMDLs in this document will be recalculated if and when the temperature standards are revised. In the meantime, we note in the TMDL where we think the current temperature standards will not be achieved. Particularly, it is those stream reaches where the CWE relationship predicts a need for greater than 100% canopy closure to be able to attain the temperature standards, which is generally all stream segments below about 4,000 feet elevation for streams supporting cutthroat trout or protected for bull trout.*

Clearly, any professional fish biologist will tell you that preferred stream temperatures for cutthroat trout are well above 10°C. If you apply this temperature standard to the CWE temperature model, it tells you that a MWMT of 9.7°C can only be maintained above 4,100 feet in elevation. Because DEQ tends to monitor water temperatures near the mouth of streams, almost every single watershed in the North Fork Clearwater River with cutthroat trout will violate this standard. This temperature standard obviously doesn't make sense especially since almost every stream in the Upper North Fork Clearwater river has cutthroat trout and many are considered to be strong populations.

An important question that needs to be answered is, should a stream that arguably has a strong and stable cutthroat trout population have a temperature TMDL?

DEQ Response: *We agree that TMDLs should not be written for streams that have strong populations of cutthroat trout when salmonid spawning is the beneficial use. But, we at DEQ feel compelled to consider whether water quality is adequate for bull trout recovery in those streams that have been identified for bull trout protection. Idaho state code and regulations are not clear on this issue and in the UNFCRS we have chosen the option of trying to address water temperature issues specific to bull trout in response to the federal regulations. There are no bull trout in any of the 303(d) listed streams that are protected for bull trout. We did not have information about what bull trout life stages should exist in any given reach of these water bodies, but we still concluded that summer temperature is likely limiting to most bull trout life stages in these streams and that temperature TMDLs are needed. Even if the temperature standard supported by IDL for bull trout (presumably 12^{o}C MWMT, as stated below) were enacted, most of these 303(d) listed streams still would exceed it.*

Unfortunately, this subbasin assessment doesn't recognize the inadequacies of the temperature standard for cutthroat trout. This subbasin assessment states, where temperature TMDL's are recommend on cutthroat trout streams, enough canopy cover should be maintained over the stream to provide a 9^{o}C daily average through August 1st. If you look in the appendices, the amount of canopy cover that it recommends be maintained over the stream will not provide a 9^{o}C daily average through August 1st. The target canopy cover amounts being recommended, according to the CWE model, will maintain a maximum summer temperature of 16^{o}C or a MWMT of 15^{o}C. These temperatures far exceed the 9^{o}C daily average through August 1st, however, we believe this is a much more realistic temperature standard.

DEQ Response: *This was an error in our understanding of the conversion tables in the CWE manual. We have made the corrections using the original CWE equations.*

We also believe the federal bull trout temperature standard (10^{o}C MWMT) is too low, especially since it is difficult to find streams in Idaho that will meet this standard. In fact, Trestle Creek (tributary of Pend Oreille lake), which arguably has one of the strongest bull trout populations in the world, does not even meet this standard. Recently, an independent expert in this field evaluated the federal bull trout standard and concluded after reviewing the pertinent literature that an appropriate maximum criterion for bull trout would be a 12^{o}C MWMT (Adams 1999). What Adams means by appropriate is this is the temperature that bull trout appear to do the best in. This doesn't mean bull trout will not thrive in warmer temperatures as many strong populations do exist in warmer water temperatures.

DEQ Response: *See comment above.*

Another problem we have with the temperature TMDL's is they are not being applied where the actual beneficial use is occurring. For example, cutthroat trout tend to spawn in small streams (1st, 2nd, and 3rd order streams), so it doesn't make sense that the spawning temperature standard is being applied to larger stream reaches where these fish are not spawning. Cutthroat trout do rear in larger stream reaches, so it would make sense that a preferred rearing temperature be maintained in these areas. However, the only rearing temperature standard that DEQ uses is the cold water biota standard, which is, the maximum water temperature shall not exceed 22^{o}C. This standard is obviously inappropriate, as native salmonids (except white fish) will avoid this warm of temperature. Typically, as water temperatures exceed 16-18^{o}C, salmonids will migrate to where cooler water temperatures occur. Obviously, an acceptable rearing temperature needs to be developed for salmonids.

DEQ Response: *Hopefully, this sort of information can be built into new water temperature standards for the state. We recognize that fish use different stream reaches for different life stages, but have not yet come up with a proposal that describes the scientific reality as needed in a state code and, at the same time, addresses the concerns of different interest groups.*

Finally, there is concern about the reliability of temperature data collected from only one sample location which, coincidentally, is one of the most open canopied segments of stream. This one sample site cannot, realistically, represent 37.6 miles of streams.

DEQ Response*: While this is true, one of the values of the CWE model is that it not only predicts the high temperatures in the lower reaches, but shows how temperatures change with elevation and canopy change in other parts of the watershed. In the end, assuming acceptance of the CWE model, the major question for most streams is not whether the continuous temperature recording site is representative of a water body, but whether the stream exhibits spatial temperature variation as predicted by CWE, or whether it has particular heat loading characteristics that should be addressed by other methods.*

Obviously, there are some serious issues that need to be addressed before temperature TMDL's portray what various fishes really require or prefer. What we recommend is, defer the development of temperature TMDL's until the DEQ and the EPA can work out more realistic standards. This is the same thing that is being recommended in other subbasin assessments. This does not mean we would ignore protecting water temperatures, as the Department would continue to apply the current CWE standards when managing riparian areas. We strongly believe these temperature standards will fully protect any fish populations in our management area. If one takes a close look at the data available, it would be hard to argue that the temperature standards used in the CWE table will not support strong/healthy fish populations.

DEQ Response: *We do not agree with the recommendation to defer temperature TMDLs, because it has in the past been an excuse for inaction on temperature problems, which we think are numerous. In the UNFCRS, we are taking a more active approach and trying to identify where temperature TMDLs make sense, in spite of the standards. Changes in the standards are going to require some in-depth analysis of the temperature problems as they occur across Idaho. Temperature TMDLs are one way of doing this* *analysis. Using the CWE model, temperature TMDLs are relatively easy to do, and will be just as easy to redo when more appropriate temperature standards are adopted. The TMDLs of the UNFCRS are showing in no uncertain terms that current standards are inappropriate for a whole subbasin, not just a few streams. In addition, using CWE gives some physical understanding to how stream temperatures are distributed across a landscape. This knowledge and understanding needs to be more widespread to build the necessary technical skill and political will to change the standards.*

Brook Trout

For Tumble Creek, it is stated that a temperature TMDL is not needed because brook trout are the only salmonid of record. We have problems with this reasoning, especially if it is going to be used in other streams where sampling indicates only brook trout occur. Brook trout are not a native species and they have been found to out compete native cutthroat trout and bull trout. In fact, brook trout are considered as a pollutant in many bull trout problem assessments and recovery plans. In northern Idaho, streams that are occupied only by brook trout most likely historically supported native species such as cutthroat trout and bull trout. Research indicates that a decline in habitat conditions (warmer temperatures or more sediment) is often all it takes to give brook trout a competitive advantage over cutthroat trout or bull trout. The temperature standard for brook trout is, the daily average temperature must not exceed 9^{o}C from October 1st to April 1st. Outside of this period a daily maximum of 22^{o}C will be allowed. This type of standard will prevent cutthroat trout or bull trout from ever recolonizing streams where brook trout have taken over. This is in direct conflict with the State and Federal bull trout problem assessments or recovery plans.

DEQ Response: *We appreciate concerns about the state's water quality standards classifying brook trout in the same category as native salmonids. On the continuum of excellent to terrible water quality, brook trout as an indicator of beneficial uses being supported is on the low end of being acceptable. A line has to be drawn somewhere between indicators of acceptable and unacceptable water quality, and the presence of brook trout has been placed on the acceptable side of the line. People can and will argue whether the line is drawn appropriately, but that is the standard at this time. We note, however, that all the temperature standards for beneficial uses are under review by DEQ and USEPA. We have forwarded these comments with respect to brook trout to the appropriate authority for consideration.*

The issue of what the presence of brook trout means in relation to the existence of other salmonid species is outside the bounds of the Clean Water Act. How brook trout interact with bull trout is an issue for the Endangered Species Act, and the effects of brook trout in relation to cutthroat is a fisheries management issue. Tumble Creek is not identified as a bull trout recovery stream; otherwise, we would have assessed it against the bull trout temperature standard.

We especially hope this type of call will not be made where the only fish sampling that occurred was near the mouth of the stream or in limited areas. In many streams, brook trout may be the only species that occur in the lower reaches while cutthroat trout or even bull trout could occur in the upper reaches.

DEQ Response*: As we noted in a comment to the Nez Perce Tribe above, the fish sample for Tumble Creek included the whole creek because it was done as part of the CNF's bio-physical study of the stream.*

What we recommend is, on streams that support only brook trout and don't have barriers that would prevent native species from recolonizing it, than standards that would support the native species of concern be applied. Based on the reasoning provided in Tumble Creek, for landowners who want fewer restrictions, it would be more advantageous for them to encourage the invasion of brook trout.

DEQ Response: *While this reasoning may be true and the recommendation could be useful, the state water quality standards do not discriminate between species.*

Sediment Issues

We approve of using the CWE process to evaluate roads and sediment delivery to streams. The Department of Lands plans on using CWE road data and other pertinent information if needed and available to determine where and why problems occur. This same data can be used to determine how to reduce the current sediment load a well as how to prevent it from occurring in the future.

It was determined in this subbasin assessment that Deception Gulch does not protect its beneficial uses because of sediment, and a sediment TMDL was developed. To reduce the sediment loading into Deception Gulch, it was recommended that the Clearwater National Forest obliterate all of the roads on high hazard landtypes. Obliterating roads is not the only technique that can be used to reduce mass failures and sediment delivery to streams, and should not be the only alternative to reduce sediment delivery. What we suggest is, recommend how much sediment delivery has to be reduced by, and then suggest different alternatives that may be effective in reducing mass failures or surface erosion. It should be up to the landowner to determine what techniques to pursue to reduce the sediment delivery. It should not matter how sediment delivery is reduced just as long as it is reduced.

DEQ Response: *This statement by IDL is correct. The primary reason we moved beyond simply determining by how much sediment must be reduced to recommendations about how to do it is because the CNF had already indicated that this would be their approach. In other cases, we would not be so bold as to determine what a land manager must do to attain the desired sediment reduction.*

Typically, focusing restoration efforts on hazardous landtypes as recommended in Deception Gulch, will give a landowner the biggest bang for the buck as far as reducing sediment delivery goes. However, on table 5.1 it shows that those watersheds that have the highest percentage of roads on high-risk landtypes had some of the lowest number and density of failures. You may want to revisit how to determine these high-risk landtypes, as at first glance they seem to predict the opposite of what you'd expect. This discrepancy could be explained if the watersheds with the most high-risk landtypes have the newest road on them. This should be investigated further before relying on these hazard ratings.

DEQ Response: *The noted discrepancy in Table 5.1 is as postulated. Those watersheds with a high percentage of high risk landtypes and low density of failures are those watersheds like Cougar and Grizzly which were roaded for logging in the 1980s after the CNF had learned to engineer for the problem; therefore, the roads are much more stable.*

Many of the sediment delivery values (back ground, current and acceptable amounts) are developed by models, which are not necessarily accurate. As a result, we should not lose track that the reason we develop TMDL's is to insure that beneficial uses are protected. Regardless of what our models say we need to always verify that our streams are responding. Often it may take considerably less or more than models indicate to restore and protect beneficial uses.

DEQ Response: *This comment is true. The TMDL process requires the development of implementation plans to meet the loading reductions. The results of the implementation plans are to be monitored with the goals of insuring that streams are responding and beneficial uses are being returned.*

We are not comfortable using the WATBAL model to predict sediment delivery rates as in some research on it has proved unreliable (contact Douglass Fitting for more information).

DEQ Response: *As we noted in above to a similar comment from the Nez Perce Tribe, we have not used the WATBAL model in any of the critical calculations or determinations for this problem assessment and TMDL (see comment above for more detail).*

Miscellaneous

On page 22 it is mentioned that some evidence suggests that canopy removal will result in lower flows in the latter part of the year, which could possibly alter stream temperature. This statement is misleading as the vast majority of the data indicates that canopy removal will result in increased low flows. The most notable case where timber harvest decreases summer low flows is on the coast where most of the summer precipitation comes from fog drip off of trees. This is not an issue in northern Idaho.

On page 35 it is stated that China Creek is not listed by either the Federal or the State Bull Trout Problem Assessment as a stream to protect for bull trout. China Creek is a tributary of Moose Creek and according to the State Bull Trout Problem Assessment, Moose Creek has a high importance to bull trout. As far as we are aware, China Creek has not been surveyed for bull trout, but because of its close proximity to known bull trout streams it should be managed as if bull trout occur there.

The Rosgen channel types are incorrect for Hem Creek, Laundry Creek, Sylvan Creek, Tamarack Creek, and Tumble Creek. Based on Rosgen's Classification Scheme, an "AA" channel Is > 10% in grade, an "A" channel is 4-10% in grade, a "B" channel is 2-4% in grade and a "C" channel is <2% in grade.

DEQ Response: *It is unclear from the comment where in the text this error occurs. However, both the DEQ BURP data and the CNF bio-physical data are generated by field crew observations. BURP crews, for example, use a modified Rosgen channel classification to record their field observations. The Rosgen classification includes other descriptive parameters for each reach channel type, and the field crews rely on a broad range of characteristics to decide on a channel type. It is not surprising that some of the observed slopes for the channel types fall outside the slope ranges given in the theoretical classification.*

For the purposes of this report, we assume that the channel types as identified by the field crews are correct. Since the channel type is presented as background and setting information, but does not figure in any of the status calls or calculations, we have not returned to the field to ensure that all the channel type calls at all locations in the report are correct.

On page 64 it is indicated that stream widening, which can increase solar input in temperature, is usually caused by the deterioration and/or removal of streamside vegetation. It should be pointed out that stream widening can be caused by agradation, which is often a response to increase sediment delivery.

DEQ Response: *Added to text of report.*

It would be nice to have the 303(d) listed stream names on the maps provided in the appendices. As is, we had to pull out the U.S. Forest Service maps to determine which streams occur where.

Mr. Curry Jones, Environmental Protection Specialist, USEPA, Region 10

Comments on the Upper North Fork Clearwater River Subbasin and TMDL

Water Quality Data Summary and Conclusions

General Comments

1. Section 6.0 proposes to delist eighteen (18) 303(d) listed waters for sediment. These waters should remain 303(d) listed for the following reasons:

The public notice developed for the Upper North Fork Clearwater TMDL did not inform the public that a delisting proposal was also included within the TMDL. The delisting proposal should go under a separate letterhead allowing the public to also comment on the delisting proposal as well.

DEQ Response: *The Subbasin Assessment and TMDL will continue to recommend the delisting for sediment of these water bodies as a conclusion of the examination and analysis of the data presented. Although DEQ believes the subbasin assessment/TMDL notice for the Upper North Fork Clearwater to have been sufficient, we will likely make a formal public notice pulling together proposed delistings from several subbasin assessments before submittal to USEPA for consideration.*

Because the new Water Body Assessment Methodology (WBAM) should address concerns raised by EPA in a May 6, 1999, letter from Randy Smith to Stephen Allred on the 1996 Water Body Assessment Guidance. EPA suggests that the Idaho Department of Environmental Quality (DEQ) postpone delisting these waters identified in Table 6.1 to allow the new WBAM to be used to determine if the beneficial use is actually impaired.

DEQ Response: *It is the state's position that proposals to delist should continue apace with the development of the subbasin assessments and TMDLs. The subbasin assessments as they are currently being conducted meet the requirements of the CWA and Idaho code.*

In the case of the water bodies of the UNFCRS, deferring delisting based on a potential beneficial use impairment decision would not help resolve the major pollution issues. The subbasin assessment has concluded that temperature and not sediment is the primary pollutant causing impairment. Temperature TMDLs have been written for all except two of the listed water bodies. One of these two, Hem Creek, is in near pristine condition. The other, Tumble Creek, currently supports brook trout in numbers that will likely meet the new WBAM requirements.

Based on these reasons stated above, the following changes in the subbasin assessment are suggested.

DEQ Response: *Based on the state's reasoning above, we do not respond to the specific comments on Sections 6.1 through 6.18. We believe the assessments in Section 6 are* *appropriate as presented. We believe that for all the water bodies of the UNFCRS, except Deception Gulch, water quality is not truly impaired due to excess sedimentation. We believe we have presented adequate documentation to support this position.*

Specific Comments

1. *Page 35, Section 6.1, Forth Paragraph*, Move Fourth Paragraph on Page 35 to Page 36, First Paragraph, Include suggested rewording, "Because it is not clear whether or not China Creek is truly impaired due to excess sedimentation, a TMDL will not be developed at this time. China Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

2. *Page 36, Section 6.2, Fifth Paragraph*, Move Fifth Paragraph on Page 36 to Page 37, Third Paragraph, Include suggested rewording, "Because it is not clear whether or not Cold Springs Creek is truly impaired due to excess sedimentation, a TMDL will not be developed at this time. Cold Springs Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

3. *Page 37, Section 6.3, Second Paragraph*, Move Second Paragraph on Page 38 Sixth Paragraph, Include suggested rewording, " Because it is not clear whether or not Cool Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Cool Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

4. *Page 39, Section 6.4, Third Paragraph*, Move Third Paragraph on Page 39 to Page 40 First Paragraph, Include suggested rewording, "Because it is not clear whether or not Cougar Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Cougar Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

5. *Page 41, Section 6.6, Second Paragraph*, Move Second Paragraph on Page 42 to Sixth Paragraph, Include suggested rewording, "Because it is not clear whether or not Gravey Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Gravey Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

6. *Page 43, Section 6.7, Third Paragraph*, Move Third Paragraph on Page 43 to last Paragraph on Page 43, Include suggested rewording, "Because it is not clear whether or not Grizzly Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Grizzly Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

7. *Page 44, Section 6.8, Fifth Paragraph*, Move Fifth Paragraph on Page 44 to Last Paragraph on Page 45, Include suggested rewording, "Because it is not clear whether or not Hem Creek is truly impaired due to excess sedimentation, a TMDL will not be

develop at this time. Hem Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

8.*Page 45, Section 6.9, First Paragraph*, Move First Paragraph on Page 46 to Fifth Paragraph on Page 46, Include suggested rewording, "Because it is not clear whether or not Laundry Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Laundry Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

9. *Page 47, Section 6.10, Fifth Paragraph*, Move Fifth Paragraph on Page 46 to Fifth Paragraph on Page 46, Include suggested rewording, "Because it is not clear whether or not Laundry Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Laundry Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

10. *Page 48, Section 6.11, Fifth Paragraph*, Move Fifth Paragraph on Page 48 to Second Paragraph on Page 49, Include suggested rewording, "Because it is not clear whether or not Middle Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Middle Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

11. *Page 50, Section 6.12, Fifth Paragraph*, Move Fifth Paragraph on Page 50 to the Last Paragraph on Page 51, Include suggested rewording, "Because it is not clear whether or not upper Orogrande Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Upper Orogrande Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment."

12. *Page 53, Section 6.13, Fifth Paragraph*, Include suggested rewording in this paragraph, "Because it is not clear whether or not Lower Orogrande Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Lower Orogrande Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

13. *Page 54, Section 6.14, Fifth Paragraph*, Move Fifth Paragraph on Page 54 to the third paragraph on Page 53, Include suggested rewording, "Because it is not clear whether or not Osier Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Osier Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

14. *Page 56, Section 6.15, Fourth Paragraph*, Move Fouth Paragraph on Page 56 to the second paragraph on Page 57, Include suggested rewording, "Because it is not clear whether or not Sugar Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Sugar Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

15. *Page 58, Section 6.16, Second Paragraph*, Move Second Paragraph on Page 58 to Fifth paragraph, Include suggested rewording, "Because it is not clear whether or not Swamp Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Swamp Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

16. *Page 59, Section 6.17, Second Paragraph*, Move Second Paragraph on Page 59 to sixth paragraph, Include suggested rewording, "Because it is not clear whether or not Sylvan Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Slyvan Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

17. *Page 60, Section 6.18, Third Paragraph*, Move Third Paragraph on Page 60 to the Last Paragraph on Page 60, Include suggested rewording, "Because it is not clear whether or not Tamarack Creek is truly impaired due to excess sedimentation, a TMDL will not be develop at this time. Tamarack Creek will be re-evaluated using the new Water Body Assessment Methodology to determine if the waterbody is impaired due to sediment. "

DEQ Response: *Based on the state's reasoning above, we do not respond to the specific comments on Sections 6.1 through 6.18. We believe the assessments in Section 6 are appropriate as presented. We believe that for all the water bodies of the UNFCRS, except Deception Gulch, water quality is not truly impaired due to excess sedimentation. We believe we have presented adequate documentation to support this position.*

Temperature TMDL

Page 64, Section 7.1.1 and Section 7.1.3 (Second Paragraph). The Temperature TMDL identifies the loading capacity as 10 C Maximum Weekly Maximum Temperature (MWMT). The TMDL then indicates that load reductions were developed and distributed appropriately throughout the watershed. What is the thermal loading being reduced and allocated. The TMDL should identify some form of a thermal loading such as BTU/ft^2/day or Langleys/day or percentage reduction in stream temperature necessary to 10 C MWMT. Although these thermal loading measures may be of limited use to land management agencies, these loading measures do provide the basis for linking the shade targets to a thermal load reduction required to meet the prescribed loading capacity and water quality standard for temperature.

DEQ Response: *We question the need for the linkage USEPA requests by noting that an increase in shade translates directly to a decrease in the manageable portion of the heat load and a corresponding decrease in water temperature. This is well documented in models such as SSTEMP. Nonetheless we have restructured all of Section 7 to show the linkages being requested. For different shading reduction targets, we identify the associated thermal loading reduction in terms of watts per square meter. We hope having done this once, it need not be repeated in other TMDLs which follow this same approach.*

Page 65, Section 7.1.3, Paragraph 4, First Sentence, The temperature TMDL indicates that heat load reductions are defined in terms temperature exceedences and heat capacity temperatures for each waterbody. Based on this, what temperature exceedence is the TMDL trying to control for? This can be determined by developing frequency distribution plot of the MWMT for each subwatershed (all years combined or seperate out years). The critical temperature you would then be controlling for is the lethal temperature that occurs most frequently. Based on this, then you can develop your temperature reduction targets needed to meet the 10 C.

DEQ Response: *The temperature exceedance that the TMDL is trying to control is shown in the plots for each water body presented in Appendix 3. We have identified the time period of late July through early August as the critical time period for which we are controlling temperatures. We are not controlling for lethal temperatures – we are controlling for the temperatures defined in the state standards. We develop our temperature reduction targets based on stream shading as the surrogate target, with percent shading at a given elevation being the target.*

Page 67, Section 7.1.5, Paragraph 2, The section indicates that loading capacities for the three impaired streams were developed using the Cumulative Watershed Effects relationship. 1. How were the loading capacities developed using CWE when the loading capacities are already identified in Section 7.1.1?

DEQ Response: *This section has been rewritten and now addresses this comment.*

In using other appropriate measures or TMDL surrogates (as provided for in 40 CFR 130.2(I)), the linkage back to the attainment of water quality standards is critical. The temperature TMDL for the Upper North Fork Clearwater River subbasin does not provide a clear linkage back to attainment of water quality standards. The following elements are critical when using TMDL surrogates:

The temperature TMDL should then identify temperature and/or thermal (i.e., thermal units - *$j/m^2/sec$ or $btu/ft^2/day$*) reduction targets needed to attain water quality standards. This reduction in stream temperature and/or thermal loading provides the basis for the linkage to the shade targets identified in Appendix 4 of the Upper North Fork Clearwater River TMDL (Table 1).

Table 1 - Example Temperature Allocation / Load Reductions

Heat Loading Capacity (equivalent to water quality standard)	Current Heat Loading	Required Heat Loading Reductions	CWE Shade Targets Needed to Meet Heat Loading (Mean Shade by Stream Reach)
450 $BTU/ft^2/day$	675 $BTU/ft^2/day$	50% Reduction	80% Shade (Amount of Shade Needed to meet the Heat Loading Capacity

DEQ Response: *We have now included the kinds of relations you note. The newly rewritten parts of Section 7 clearly link heat loading to the surrogate targets. We continue to present load reductions in terms of the surrogate target, percent shade, because it is the only measure that makes sense for implementation. The relations between percent shade and insolation heat load are presented in Sections 7.1.1, 7.1.2, and 7.1.3 such that they may be easily calculated by anyone who needs them. The CWE shade and elevation versus water temperature regression provides a quantified linkage between shade and water temperature.*

Concerns with Cumulative Watershed Effects (CWE) Model as the only Tool in the Temperature TMDL

As stated in the October 30, 2000, comment letter on the Upper North Fork Clearwater River Subbasin Assessment, EPA has some concerns regarding the use of the Cumulative Watershed Effects (CWE) process in the development of the temperature TMDL for the Upper North Fork Clearwater River subbasin. EPA understands that DEQ has contracted with Western Watershed Analyst to complete a comparison study between the Stream Segment Temperature Model (SSTEMP) and CWE to determine if both yield similar results. If the results from Western Watershed Analyst show that the modeling results between CWE and SSTEMP are similar, the TMDL should take the next step to integrate a thermal loading component, as displayed in Table 1 above.

DEQ Response: *We have done as you requested. The Western Watershed Analysts results are included as an appendix to the document. Although we have done as requested, we believe we have gone beyond what is required, and note that the exercise will add little if any utility to the TMDL nor change its implementation.*

Sediment TMDL

Page 62, Paragraph 3, The TMDL sets a goal of 225% over background sediment load (= 430 tons/year) as the level beyond which sediment loading would be considered excessive. Based on this goal, Deception Creek, as defined by the Clearwater National Forest, would only be protected and expected to meet a *Low Fishable* goal. Under this *Low Fishable* goal, Deception Creek would only be expected “to maintain habitat potential that supports a minimal harvestable surplus of fish.” The designated beneficial use which is to be protected is salmonid spawning. Currently the Idaho WQS do not sub-categorize the salmonid spawning use. Therefore it is not appropriate to establish a “low fishable” goal for salmonid spawning for this particular waterbody. By taking an approach, which interprets the salmonid spawning use for this waterbody to be “low fishable” you are effectively establishing a sub-category of the salmonid spawning use. This is inconsistent with the current WQS in Idaho. Idaho could establish sub-categories for the salmonid spawning beneficial use, but this would require a formal revision to their water quality standards. Again, this does not currently exist in Idaho's WQS. EPA believes that refining beneficial uses by establishing sub-categories is by far a much better and accurate approach than an approach which would try to define uses more broadly so that they fit all waters.

DEQ Response*: We are merely making an interpretation of our water quality standards. We are not establishing a new use. We are establishing that the CNF "low fishable" goal meets or exceeds full support of salmonid spawning as codified in Idaho administrative rules. To further understand our response here, please review our response above to the CNF's comment about our use of their "low fishable" goal.*

There is some confusion between CNF data and goals, and our use of their data in establishing the narrative standard for sediment in Deception Gulch to meet Idaho's water quality standards. Salmonid spawning is the beneficial use that must be supported under Idaho's water quality standards. The CNF's data were analyzed to determine what level of sediment could be tolerated and still support salmonid spawning. We did not intend to establish a sediment target that approaches pristine conditions because we believe there is a level of sediment over background that meets the state's water quality standards and the intent of the CWA.

The CNF's "low fishable" goal is not being considered as a subcategory of salmonid spawning. What we're essentially looking at is a continuum of sediment that could be added to Deception Gulch, and deciding at what level salmonid spawning would no longer be supported; what loading still meets water quality standards? The CNF, based on their data, has determined that a viable population of fish would be supported at 450% sediment loading over background, and that with 225% sediment loading over background, that fish population would also support low fishing pressure. By selecting 225% over background as our TMDL target, we are not creating a subcategory of salmonid spawning that equates to low fishable. We are in fact establishing a 100% margin of safety over the CNF's conclusions that 450% sediment loading over background would support a viable population. It is coincidence that the CNF's low fishable category corresponds to what we determined is needed as a margin of safety.

Because the goal of water quality standards is to set a level of protection necessary to prevent degradation of an existing use, this TMDL should identify a background sedimentation rate which would prevent further degradation of the existing use. How was the level of fishability determined for streams in the Upper North Fork Clearwater River?

DEQ Response: *Using the WBAG plus process, we determined that salmonid spawning was not being fully supported in Deception Gulch, and the existing use is less than the target being set for this water body. For the other water bodies being assessed, the existing use equates to the salmonids present. Fishability is not an existing use under Idaho water quality standards. In fact, however, if fishability were an existing use, the UNFCRS has stable or improving populations of fish. Given the CNF's active program of road obliteration and their full implementation of INFISH, one could not argue that any degradation of existing use is occurring as a function of sediment.*

Appendix 15. Response to USEPA Recommendations for Revisions

Appendix 15. Response to USEPA Recommendations for Revisions

October 2003

Mr. David Mabe, State Water Quality Programs Administrator for DEQ submitted the *Upper North Fork Clearwater Subbasin Assessment and Total Maximum Daily Loads* to USEPA for approval on March 26, 2001. On December 10, 2001, DEQ received a letter dated December 6, 2001, from Mr. William Stewart, Region 10, USEPA, recommending further revisions. The letter and DEQ's responses follow:

USEPA Letter

December 6, 2001

Dear Tom:

This is in regard to our telephone conversation on December 4, 2001 concerning the *Upper North Fork of the Clearwater River Subbasin Assessment and TMDL*. This is to clarify my understanding of our conversation and to identify changes that we are recommending for the document.

After careful evaluation of the Cumulative Watershed Effects (CWE) method, it is our conclusion that results generated by the CWE nomographs do not provide an accurate or precise means to predict stream temperature response. We concluded that using CWE results as TMDL shade targets may result in a prediction that underestimates the level of shade needed. This is because CWE, like many models, is not a precise or accurate tool for predicting stream temperature response. The data on which it relies to calculate predictions of shade is very limited and the assumptions of the approach only address two of the many variables that affect stream temperature.

In the Upper North Fork of the Clearwater River TMDL, the IDEQ has used CWE to predict how much shade is sufficient at any given elevation to meet the state's water quality standards and uses these results as TMDL targets. While we recognize that CWE can be a useful screening tool to help land managers, we are concerned about the accuracy in predicting stream temperature response. EPA and DEQ have agreed to adopt sideboards to shore up the limitations in the method. The following changes are recommended for the Upper North Fork of the Clearwater River TMDL targets.

In Appendix 4 through Appendix 11 of the document, the column titled TARGET CANOPY (%) should be modified to reflect the following:

- If the existing canopy (%) is less that what CWE predicts is necessary to achieve the state's water quality standards, it is acceptable to use CWE results as the interim TMDL target and no change is necessary in the target.

- If the existing canopy (%) is greater than what CWE predicts is necessary to achieve the state's water quality standards, the TMDL target canopy (%) should be set at the existing canopy (%). This will ensure that CWE derived predictions will not result in a reduction of shade below current levels in impaired water bodies.

These changes reflect an agreement reached between Regional EPA management and Dave Mabe in a meeting held on October 10, 2001.

In the subbasin assessment under "*7.2.2 Excess Sediment Load*," there is a discussion concerning the Clearwater Nation Forest Plan (USFS 1987). Paragraph one states, "According to the CNF Forest Plan (USFS 1987), the water quality objective for this watershed is 255 percent over background (about 430 tons per year loading), which is described as "Low Fishable." Amendment No. 26 of the Clearwater National Forest Plan updates the water quality objectives in Appendix K of the CNF Forest Plan for Deception Gulch and other streams in the watershed. Deception Gulch is now listed by the USFS as a <u>Moderate Fishable</u> stream which would indicate a target of 150 percent increase of sediment over natural yields for no more than 10 out of 30 years. Please find a copy of Appendix B of *Forest Plan Amendment No. 26* attached.

One method to set targets for the Deception Gulch sediment TMDL would be to use sediment data from similar streams in the Clearwater River watershed which are fully meeting their beneficial uses as reference conditions. I believe this would help in the development of defensible targets for this TMDL. A table comparing natural background, percent over natural loading, modeling results, mass failures, etc. for reference streams and Deception Gulch would go a long way in explaining and supporting the targets.

Please feel free to give me a call at (208) 378-5753 if you want to discuss this matter further.

Sincerely,

William C. Stewart

cc: Marti Bridges
Christine Psyk

DEQ Response:

Appendix 4 through Appendix 11 have been changed as recommended. The temperature TMDLs in this document show the targets calculated using the method recommended by USEPA.

The sediment TMDL for Deception Gulch has been substantially revised to clarify the choice of target. As recommended, Table 16 has been added showing comparisons of numerous data types between Deception Gulch and a suite of reference watersheds with similar geology, landforms, and stream characteristics, one of which is unroaded. A discussion of the reference data has been added, showing its relation to the selected targets. Additional data from the Clearwater National Forest (CNF) have been added, showing that Deception Gulch supports a healthy population of salmonids, including juveniles.

In addition, the CNF has provided the data contained in the following table identifying roads that have been treated in Deception Gulch and the surrounding area. As pointed out by the CNF, "[i]t is difficult to separate out what is Deception Gulch alone. Some of the road oblit is in face drainages and in Comet Creek." However, if one simply looks at work done in fiscal year 2002 when all work was in Deception Gulch, 15 miles of roads were treated, which is about 75% of the recommended number of miles of roads to be treated by the TMDL. It is safe to assume that the majority, if not most, of the roads treated were on high risk landtypes, since the TMDL had identified that as a problem. A similar number of miles of roads were scheduled to be treated in fiscal year 2003, but funding was lost at the last minute. The CNF has a plan in place to meet the targets of the TMDL. It is reasonable to expect that the CNF will exceed the targets set by the TMDL once funding is acquired to finish the plan.

Table 15-1. Road obliteration in Deception Gulch and the surrounding area.

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
Deception and Comet	**99**		**Deception and Upper North Fork**					
		729	Comet Creek	0.7		1.1		1st 4.4 miles on system - mtc level 3
		729A	North Fork	1.6		2.3		LTIU paid for by NFIF
		74568	Comet Creek	1.4				
		74572	North Fork	1.0				
		74573	North Fork	1.4				
		74574	North Fork	0.5				
		74575	North Fork	1.1				
		74576	North Fork	0.3				
		729-T1	North Fork	0.3				
		729-T3	North Fork	0.6				
		729-T4	North Fork	0.9				
		729-T7D	Comet Creek	0.7				
		729A-T1/T4	North Fork	0.6				
		729A-T5	North Fork		0.7			
		729A-T6	North Fork		0.5			
		729A-T7	North Fork		0.5			
		729A-T8	North Fork		0.8			

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		729A-T9	North Fork		0.9			
		729A-T10	North Fork		0.8			
		729A-T11	North Fork		0.1			
		729A-T12	North Fork		0.6			
Deception and Comet Totals				**11.1**	**4.9**	**3.4**		
730 Road and spurs	**01**		**Deception and Upper North Fork**				**25,000**	**$6,378**
		730		5.4		5.0		Approximately 7 miles to have ATV trail constructed
		730A		0.6				
		730B			0.5	0.2		
		730C				0.5		
		730E			0.5			
		732		1.2				
		5444				0.2		
		74554		0.4		0.4		
		74567		0.5		0.8		
		74569		1.0				

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		830054		0.2				
		830059		0.9				
		830071			0.3			
		830311			0.8			
		830312			0.2			
		830313			0.2			
		830319			0.2			
		830320		0.1				
		830321		0.1				
		830323		0.8				
		830385			0.3			
		830403			0.1			
		830405			0.1			
		830415			0.3			
		830416			0.1			
		830417		0.1				
		830422			0.1			
		830425			0.1			
		830426			0.2			
		830476		0.6				

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		830500			0.3			
		730-T101			0.1			
		74554-T1				0.4		
		74554-T1A			0.1			
		74554-T2				0.2		
		830311-T1			0.3			
730 Road and spurs Totals				**11.9**	**4.65**	**7.7**		
Road 729 and spurs	**01**		**North Fork Face Drainages**				**25,000**	
		729B		1.8		0.1		
		74571		0.7				First 0.8 and last 0.2 miles to be ATV trails
		74571				0.5		
		830072		0.7				
		830073			0.4			
		830399			0.2			Left open to ATV use
		830400			0.2			
		830401			0.1			
		830402			0.1			

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		830404			0.3			
		830427			0.1			
Road 729 and spurs Totals				**3.2**	**1.4**	**0.6**		
Deception Gulch 02	**02**		**Deception Gulch**				**Equipment costs only**	
		734A		1.0		0.8	4,945	LTIS segment was abandoned
		74557		0.1			495	
		830063		1.3			6,429	
		830063/T1			0.1			
		830066		1.3			6,429	
		830067		0.7			3,462	
		5442				0.7		LTIS segment was abandoned
		830062		1.1			5,440	
		830062/T1			0.4			Abandoned
		830309			0.4			Abandoned
		830067/T1			0.1			Abandoned
		830067/T2			0.1			Abandoned
		830067/T3			0.1			Abandoned

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		830067/T4			0.1			Abandoned
		830067/T5			0.1			Abandoned
		830067/T6			0.1			Abandoned
		830067/T7			0.1			Abandoned
		830067/T8			0.1			Abandoned
		830067/T9			0.1			Abandoned
		830067/T10			0.1			Abandoned
		830067/T11			0.1			Abandoned
		830067/T12			0.1			Abandoned
		830067/T13			0.1			Abandoned
		830067/T14			0.1			Abandoned
		830067/T15			0.1			Abandoned
		830065		1.3			6,429	Big draws/wide road
		830288		0.2			989	Big draws/wide road
		830069		0.2			989	Big draw/strong outslope
		830068			0.5			Abandoned
		830239		0.2			989	
		830289			0.2			Abandoned
		830064		1.0			4,945	Big draws/wide road
		830476		1.4			6,923	Big draws/wide road

Roads	FY[1]	Road Number	Watershed	Oblit-erated	Aban-doned	LTIU[2]	Expend-iture	Comments[3]
				(mi)	(mi)	(mi)	$	
		830306		0.6			2,967	Big draws/wide road
		5445				0.6	2,967	One third abandoned; two thirds 10% outslope
		830060		0.3			1,484	Seeps
Deception Gulch 02 Totals				**10.7**	**3.1**	**2.1**	**55,882**	

[1] FY = fiscal year
[2] LTIU = long term intermittent use
[3] **Comments** are as received from the CNF and may not be fully meaningful in this document